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Skin Sense – An IoT & ML Approach to Skin Health Management Developments

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***Abstract*—The skincare industry is booming, with an ever-increasing market share. In 2024, the Skin Care market is projected to generate a revenue of US$186.60 bn worldwide. Our project not only aligns with this growth but also contributes by offering a technologically advanced solution to skincare enthusiasts. Due to lack of awareness of personal skin type or condition, the influence of marketing strategies, and the prevalence of conflicting skincare advice, consumers often resort to a trial-and-error approach, exposing their skin to potential risks and frustrations. The modern brands readily provide different formulation of skincare product based on the type and condition of different consumers, but people often fail to choose the right products and to recognize their own skin needs. By merging IoT, computer vision, and machine learning, we empower individuals to make informed decisions about their skincare, promoting both health and beauty. This project aims to go beyond simple skin type detection; identification of anomalies, differentiation between various skin conditions, and, where necessary, providing tailored skincare recommendations. From daily skincare routines to addressing severe medical cases, including skin cancer detection, our project tries to guide users towards healthier and more radiant skin**

***Index Terms*— Internet of things, Raspberry pi, Machine learning, Skin monitoring, Real time analysis.**

I. INTRODUCTION

In the ever-evolving realm of skincare, our project and research embarks on a journey to redefine how we understand and care for our skin. The Face Skin Health Analyzer and Recommendation represents a convergence of cutting-edge technologies—IoT, machine learning, and computer vision. This innovation is poised to leave an indelible mark on an industry that is not just a trend but also a health care for individuals. The goal is ambitious yet practical—to empower individuals with an intelligent skincare solution that goes beyond routine skin type detection. Instead, we aspire to delve into the identification of anomalies, differentiation between diverse skin conditions, and the delivery of tailored skincare recommendations. At the heart of our project is the fusion of Raspberry Pi's computational power and state-of-the-art YOLO v7 machine learning model [1].

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Deployed on a Raspberry Pi, the model analyzes real-time images from a Pi camera or in our case, a DSLR camera, augmented by oil level of skin driven from the sensor. The result is a compact facial skin analyzer that goes beyond identifying skin types, offering personalized skincare recommendations. The end result of the project is in providing users with a proactive tool that not only enhances their skincare routines but also detects potential skin cancer early, reducing the financial burden on individuals. In a dynamic era of skincare, our project exemplifies a convergence of technology and health, aiming to empower users toward healthier, more radiant skin [2].

II. Literature Reviews / Surveys

A number of authors have worked on the topic taken by us, here, we present a few of them as follows below.

- Li, P., Yu, H., Li, S., & Xu, P. *Comparative Study of Human Skin Detection Using Object Detection Based on Transfer Learning.* Institute of Rehabilitation Engineering and Technology, University of Shanghai for Science and Technology, Shanghai, China; Department of Biomedical Engineering, Chang Zhi Medical College, Changzhi Shanxi, 09 Apr 2021, Accepted 20 Oct 2021, Published online: 03 Mar 2022
- K. Roy, S. S. Chaudhuri, S. Ghosh, S. K. Dutta, P. Chakraborty, and R. Sarkar, "*Skin Disease detection based on different Segmentation Techniques*," 2019 International Conference on Opto-Electronics and Applied Optics (Optronix) , Kolkata, India, 2019, pp. 1-5, doi: 10.1109/OPTRONIX.2019.8862403.
- J. Rathod, V. Waghmode, A. Sodha and P. Bhavathankar, "*Diagnosis of skin diseases using Convolutional Neural Networks*," 2018 Second International Conference on Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, 2018, pp. 1048-1051, doi: 10.1109/ICECA.2018.8474593.
- Aishwarya N, Manoj Prabhakaran K, Frezewd Tsegaye Debebe, "*Skin Cancer diagnosis with Yolo Deep Neural Network*", The 6th International Conference on Emerging Data and Industry (EDI40) March 15 -17, 2023, Leuven, Belgium Department of ECE, Amrita Vishwa Vidyapeetham, Amrita School of Engineering, Chennai, India

The papers used by us for the survey have provided us with various insights and knowledge on how to proceed with our projects. The application of machine learning in dermatology, research by J. Rathod, V. Waghmode, A. Sodha and P. Bhavathankar, "*Diagnosis of skin diseases using Convolutional Neural Networks*," showcasing the potential of machine learning algorithms in diagnosing various skin conditions. Our project builds upon these foundations by incorporating a CNN model trained on a diverse dermatological dataset, emphasizing the significance of advanced neural networks in achieving accurate skin analyses. Furthermore, research contributions such as Li, P., Yu, H., Li, S., & Xu, P. Comparative Study of Human Skin Detection Using Object Detection Based on Transfer Learning] and [K. Roy, S. S. Chaudhuri, S. Ghosh, S. K. Dutta, P. Chakraborty and R. Sarkar, "*Skin Disease detection based on different Segmentation Techniques*," have delved into the integration of CNNs for facial recognition and analysis. These studies highlight the robustness of CNNs in image processing tasks, particularly in recognizing intricate patterns and features crucial for dermatological analyses. Our project aligns with this literature, utilizing CNNs as a key component in our facial skin analyzer to enhance the accuracy of skin type and condition detection [1]-[23].

III. Architecture

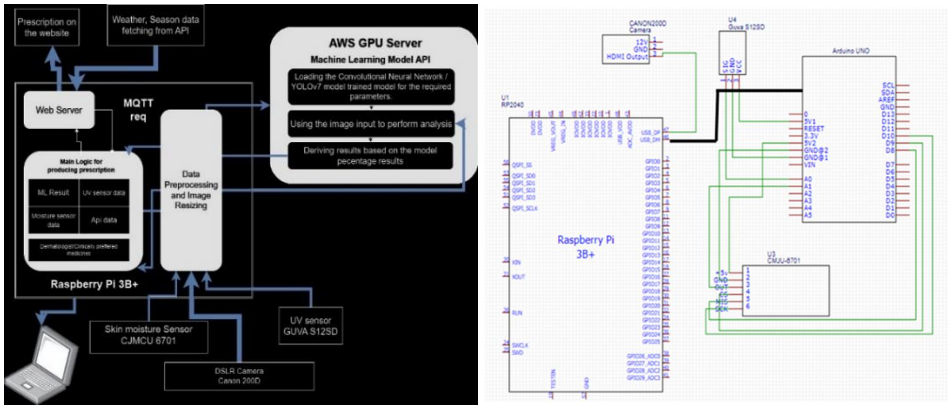

Fig. 1: The Architecture of the Face Skin Health Analyser and Recommendation System & Front end of the circuit diagram (component layout)

The Fig. 1 gives the Architecture of the Face Skin Health Analyser and Recommendation System & Front end of the circuit diagram (component layout). At the core of this project is the Raspberry Pi 3B+ single-board computer, which serves as the central processing unit. This compact yet powerful device provides the necessary computational power to drive the various components of the system. Complementing the Raspberry Pi are specialized hardware sensors, including the Skin Moisture Sensor CJMCU 6701 and the UV Sensor GUVA S12SD. The Skin Moisture Sensor measures the user's skin hydration levels, providing crucial data for the skin analysis, while the UV Sensor monitors exposure to harmful ultraviolet radiation, which can significantly impact skin health. As both of these sensors produce analog values, but Raspberry Pi 3B+ only support digital pins, we are using an Arduino Uno as our Analog to Digital Converter due to its advance library support for sensors [4].
The system's visual input is captured by a high-quality DSLR Camera, the Canon 200D, which delivers detailed and accurate images of the user's face. The gphoto2 package for Raspberry Pi which is used to control a DSLR remotely using a python script is loaded on Pi 3 and the images are captured by it. The logic behind how this works is, on running the script, the DSLR automatically captures an image and transfers it to Pi 3 via data cable and stores it in a desired folder. This image is then picked up by our ML client and is sent to processing and resized by dedicated modules, preparing them for the machine learning analysis. This photo is later deleted by the gphoto2 script to avoid overloading of images. The machine learning backbone of the project is powered by the AWS GPU Server, which hosts the YOLOv7 (You Only Look Once version 7) convolutional neural network model. This state-of-the-art computer vision model is responsible for analysing the captured images, detecting and classifying various skin conditions and anomalies [5].
The AWS GPU Server exposes a Machine Learning Model API using FastAPI, which the web server utilizes to perform the skin analysis and derive the personalized results. To facilitate seamless communication between the hardware components and the web server, the project employs the MQTT (Message Queuing Telemetry Transport) protocol. This lightweight and efficient messaging system enables the real-time exchange of data, ensuring a responsive and integrated user experience. The web server acts as the central hub, handling user requests, fetching weather and season data from an external API, and presenting the personalized skincare recommendations to the user [6].

IV. Hardware Components

1. Raspberry Pi 3B+: This single-board computer serves as the central processing unit, providing the computational power required for the project [7].
2. Skin Moisture Sensor CJMCU 6701: This sensor is used to measure the moisture level of the user's skin, providing additional data for the skin analysis [8].
3. UV Sensor GUVA S12SD: This sensor is responsible for detecting the UV radiation levels, which can have a significant impact on skin health [9].
4. DSLR Camera Canon 200D: The high-quality camera is used to capture detailed images of the user's face for computer vision analysis [10].

V. Software Technologies

- Training Environment : Google Collab, Kaggle, AWS EC2
- Languages: Python(TensorFlow, Numpy), C++
- Developmet: Node.JS, HTML, CSS, Javascript, React, FastAPI, Django
- Protocols: MQTT, HTTP
- API: weather-api from Rapid API

By integrating these various technologies, the Face Skin Health Analyzer and Recommendation System creates a comprehensive and intelligent solution that empowers individuals to take control of their skin health and beauty [11].

VI. Coding Technology w.r.t. the Proposed Methodology

The proposed methodology can be elaborated in the steps down below[12]

A. Preparing Datasets

- Using an open-source Kaggle competition dataset scraped from a dermatologist website.
- Kaggle: https://www.kaggle.com/datasets/haroonalam16/20-skin-diseases- dataset

- Using the above dataset, we could have 20 relevant and common skin diseases as parameters from the dataset.
- Acne, Actinic Carcinoma, Atopic Dermatitis, Bullous Disease, Cellulitis, Eczema, Drug Eruptions, Herpes HPV, Light Diseases, Lupus, Melanoma, Poison IVY, Psoriasis, Benign Tumors, Systemic Disease, Ringworm, Urticarial Hiv es, Vascular Tumors, Vasculitis, Viral Infections.
- The dataset is irregular with 700-800 images for popular skin diseases and 150 - 300 images for uncommon diseases. Totally comprising over 6000 images.
- This is further renamed and divided into training sets and testing sets that are mutually exclusive.

B. Working of the main project module

This project was implemented using two capable deep learning state of the art models[13]

- The deep learning model (YOLO v4) is fast-trained to predict parameters of common skin conditions like Melanoma, acne, scars, cold sores, pigmentation, and many more to come up with recommendations, prescriptions, and warnings. The GPU requirements vary from 2GB-8GB

Tools used (hardware/software) [14]

Raspberry Pi 3, Python (NumPy + PyTorch + TensorFlow + Pandas + Keras) OpenCV on the Raspberry Pi 3, Pi Camera (5MP), MQTT protocol for communication, Nvidia Video Card (1050)

Problems faced by YoloV4 [15]

- Datasets were to have bounding boxes and XML data, which was impossible to generate for
- Object detection was far fetched, the current problem needed for image classification
- Estimated Time for training was 18hrs+ on Collab/Kaggle/AWS
- Using the latest CNN (convolution neural networks) comprising of the input layer, an output layer, and various hidden layers.

A CNN-based model specifically designed to classify images into different predefined classes. It learns to extract relevant features from input images and map them to the corresponding pre-defined classes. This model is slow to train and requires a minimum 2GB of GPU. Although this can be tackled by Kaggle Cloud. CNN parameters: target_size=(128, 128, 3), batch_size=32, class_mode='categorical', epochs: 20 [16]

Advantages of CNN [17]

- Labeled Dataset is enough to work.
- Performs Image Classification with ease, suitable for our use case.
- Estimated Time for training was 8hrs+ on Collab, 10hrs on Kaggle After the training and testing results are obtained, we export the model in .h5 format.

C. Build an IoT Architecture and Circuit [18]

The circuit shown in Fig. 1 is built onto which the training model is loaded which performs the analysis of skin of any subject whose images are taken from the camera module. Here two main sensors are used for moisture detection and UV detection through the Raspberry Pi digital pins. In the context of the project, the Internet of Things (IoT) architecture is pivotal in creating a cohesive framework for seamless integration and interaction among the project's diverse components. The architecture is tailored to accommodate the specific needs of our facial skin analysis system, leveraging key elements to optimize data flow, communication, and decision-making [19].

1. **Device and Sensor Layer**: This foundational layer encompasses the physical devices and sensors responsible for capturing real-time facial images and relevant data. These devices play a pivotal role in gathering primary information about the user's skin conditions. The sensors used here to gather information are the UV sensor, Moisture Sensor, and the Camera Module. The Fig. 2 gives the simulation results & overall block-diagram [20].

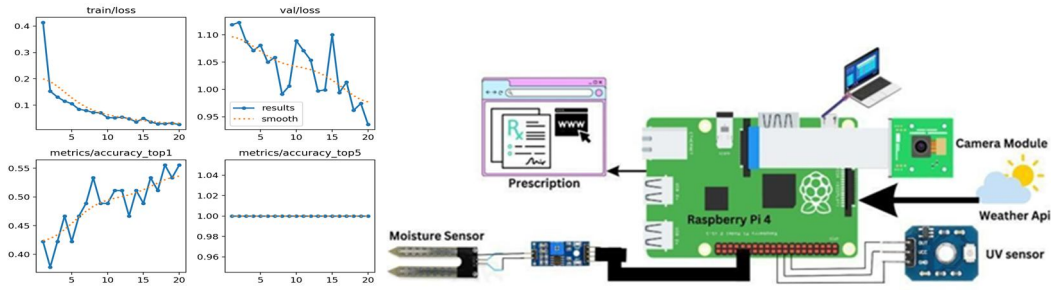

Fig. 2: Simulation results & Overall block-diagram

epoch	train/loss	metrics/accuracy_to	metrics/accuracy_to	val/loss	lr/pg0	lr/pg1	lr/pg2
1	0.41417	0.42222	1	1.1182	0.00023747	0.00023747	0.00023747
2	0.15307	0.37778	1	1.1226	0.00045193	0.00045193	0.00045193
3	0.13097	0.42222	1	1.0876	0.00064283	0.00064283	0.00064283
4	0.11525	0.46667	1	1.0711	0.00060797	0.00060797	0.00060797
5	0.10579	0.42222	1	1.0808	0.00060797	0.00060797	0.00060797
6	0.0845	0.46667	1	1.0498	0.00057263	0.00057263	0.00057263
7	0.08006	0.48889	1	1.0586	0.00053728	0.00053728	0.00053728
8	0.07212	0.53333	1	0.99161	0.00050194	0.00050194	0.00050194
9	0.07122	0.48889	1	1.0062	0.0004666	0.0004666	0.0004666
10	0.05289	0.48889	1	1.0889	0.00043126	0.00043126	0.00043126
11	0.05192	0.51111	1	1.0709	0.00039591	0.00039591	0.00039591
12	0.05479	0.51111	1	1.0535	0.00036057	0.00036057	0.00036057
13	0.04881	0.46667	1	0.99723	0.00032523	0.00032523	0.00032523
14	0.03671	0.51111	1	0.99922	0.00028988	0.00028988	0.00028988
15	0.04982	0.48889	1	1.1	0.00025454	0.00025454	0.00025454
16	0.03644	0.53333	1	0.99431	0.0002192	0.0002192	0.0002192
17	0.02919	0.51111	1	1.0132	0.00018385	0.00018385	0.00018385
18	0.03025	0.55556	1	0.96194	0.00014851	0.00014851	0.00014851
19	0.0313	0.53333	1	0.97431	0.00011317	0.00011317	0.00011317
20	0.02687	0.55556	1	0.93598	7.78E-05	7.78E-05	7.78E-05

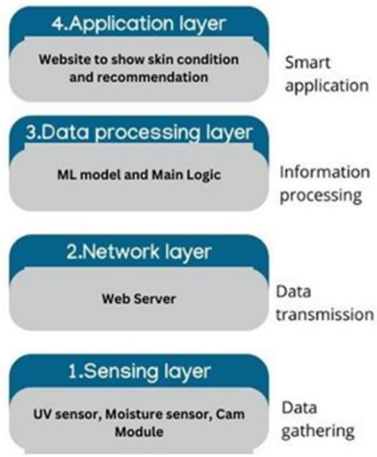

Fig. 3: Quantitative Results of the simulation & Proposed block-diagram

Fig. 4 : Simulation results

2. **Connectivity Layer**: Situated above the device layer, the connectivity layer ensures seamless and reliable data transmission from the devices to the Raspberry Pi, our central processing unit. This involves the implementation of the web server and Render serves as the hosting platform for our web server, leveraging Node.js for backend server-side scripting. Node.js excels in handling asynchronous operations, making it well-suited for managing real time data streams, such as those generated by facial image-capturing devices. The Fig. 3 gives the quantitative results of the simulation & proposed block-diagram [21].

3. **Processing and Analysis Layer:** Positioned as the middleware, this layer processes and manages facial image data effectively. Tasks such as filtering, aggregation, and protocol translation are handled here, ensuring that pertinent information is ready for analysis by subsequent layers. The Processing and Analysis Layer in our Face Skin Health Analyzer employs Convolutional Neural Networks (CNNs) to meticulously analyze facial images. The main logic, rooted in sophisticated feature extraction, categorizes skin types and identifies conditions based on a trained dataset. This layer seamlessly integrates insights from a pH diode, enhancing the system's ability to provide real-time, personalized skincare recommendations. The culmination of CNN-based analysis and intricate logic ensures prompt and nuanced feedback, empowering users with precise insights for optimal skin health. The Fig. 4 gives simulation results along with few other simulation results in Fig. 5 [22].

4. **Application and User Interface Layer**: At the topmost layer, our architecture focuses on applications and services dedicated to facial skin analysis. This layer interprets processed data to generate personalized skincare recommendations and insights into skin health conditions. The user interface (UI) presents this information to end-users through an accessible and user-friendly platform, potentially in the form of a display dashboard. In essence, our IoT architecture is purpose-built to harmonize the complex interplay of components in our project, fostering an efficient and integrated system for facial skin analysis 10 and personalized skincare recommendations [23].

5. Putting together APIs and ML : with pre-deterministic code of recommendations: A public weather API data is fetched from the node.js backend running on the PI server and the data from the sensors and ML, all

together become the input to our recommendations system and then analysis and recommendations are produced based on it [10].

VIII. TOOLS USED FOR THE PROJECT WORK

The software tool that is going to be used for the project work is:

- Training Environment: Google Collab, Kaggle, AWS EC2 –
- Languages: Python(TensorFlow, CNN, Numpy), C++
- Development: Node.JS, HTML, CSS, Javascript, React, MongoDB
- Protocols: MQTT, HTTP
- API: weather-API

The hardware that is going to be used for the project work is (real-time implementation):

- Raspberry PI 4 – development board
- pH electrode and board – PH detection
- UV Sensor – UV detection
- Camera Module – capture Real-Time Images

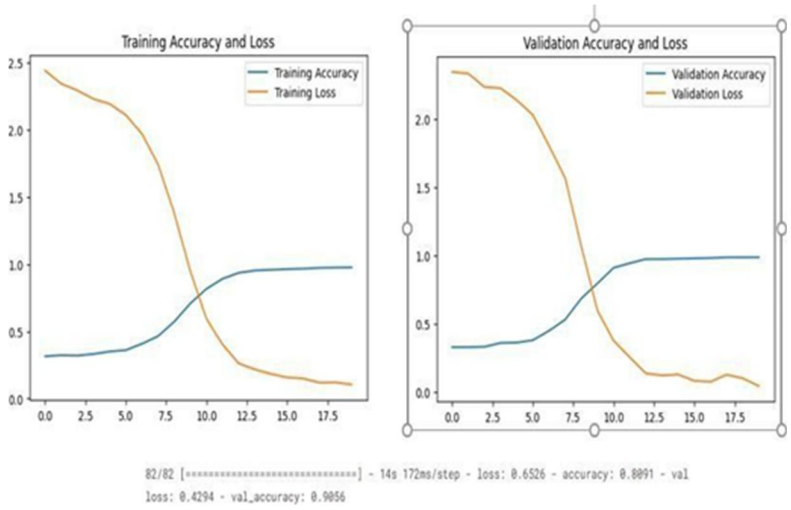

Fig. 5: Simulated Results of the graphs

IX. SIMULATION & EXPERIMENTAL RESULTS

The results obtained from this phase project demonstrate the efficacy of the integrated Convolutional Neural Networks (CNNs) in providing insightful and personalized skin analyses. Through extensive training on a diverse dermatological dataset and subsequent fine-tuning, the CNN model showcased a high degree of accuracy in recognizing and categorizing various skin conditions. In real-time image processing, CNN's ability to accurately identify skin types and conditions was evident. The system's proactive approach to identifying serious skin conditions aligns with our project's overarching goal of promoting both health and beauty.

Overall, the results underscore the success of our integrated approach, combining CNNs with IoT and machine learning, in creating a powerful and comprehensive tool for facial skin analysis. This can be seen by the Work carried out till now, Simulation Results or Experimental Results of the CNN Training Accuracy and Validation Accuracy. Also the prediction of the model on the test set shown in figures below it can be observed that as the number of epochs increases, the training accuracy also increases which results in decrement in training loss. The figure compares the theoretical graph with the resultant graph.

X. CONCLUSIONS

In conclusion, our final year project represents a significant stride in the realm of skincare technology. The development of a face skin health analyzer and advisor underscores our commitment to innovation and practical application of emerging technologies. By seamlessly integrating the capabilities of Raspberry Pi and cutting edge computer vision algorithms such as CNNs, we present a pioneering solution that redefines the approach to face skin analysis and skin care recommendations. In a time when skincare extends beyond mere trendiness, our

project taps into the booming skincare industry, offering a technologically advanced tool to enthusiasts. Through the convergence of IoT, computer vision, and machine learning, our project not only aligns with industry growth but also empowers individuals to make informed decisions, promoting both health and beauty in an increasingly connected world.

REFERENCES

[1] Li, P., Yu, H., Li, S., & Xu, P. Comparative Study of Human Skin Detection Using Object Detection Based on Transfer Learning. Institute of Rehabilitation Engineering and Technology, University of Shanghai for Science and Technology, Shanghai, China; Department of Biomedical Engineering, Chang Zhi Medical College, Changzhi Shanxi, 09 Apr 2021, Accepted 20 Oct 2021, Published online: 03 Mar 2022

[2] K. Roy, S. S. Chaudhuri, S. Ghosh, S. K. Dutta, P. Chakraborty, and R. Sarkar, "Skin Disease detection based on different Segmentation Techniques," 2019 International Conference on Opto-Electronics and Applied Optics (Optronix) , Kolkata, India, 2019, pp. 1-5, doi: 10.1109/OPTRONIX.2019.8862403.

[3] J. Rathod, V. Waghmode, A. Sodha and P. Bhavthankar, "Diagnosis of skin diseases using Convolutional Neural Networks," 2018 Second International Conference on 16 Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, 2018, pp. 1048-1051, doi: 10.1109/ICECA.2018.8474593.

[4] Aishwarya N., Manoj Prabhakaran K, Frezewd Tsegaye Debebe, "Skin Cancer diagnosis with Yolo Deep Neural Network", The 6th International Conference on Emerging Data and Industry (EDI40) March 15 -17, 2023, Leuven, Belgium Department of ECE, Amrita Vishwa Vidyapeetham, Amrita School of Engineering, Chennai, India.

[5] Suma M.R. and Dr. Madhumathy P., "Hybrid Cloud-Intra Domain Data Security and to Address the Issues of Interoperability", International Journal of recent technology and Engineering (IJRTE), ISSN: 2277-3878, Published By - Blue Eyes Intelligence Engineering and Sciences Publication, A Scopus Indexed Journal, Volume 8, Issue-1, pp. 340-344, June 2019.

[6] M.R. Suma, P. Madhumathy, "Acquisition and Mining of Agricultural Data using Ubiquitous Sensors with Internet of Things", Springer Book Chapter in the book - Lecture Notes on Data Engineering and Communications Technologies, Edited by Smys, S., Bestak, R., Chen, JZ., Kotuliak, I. (eds), pp. 249-261, vol 15, Online ISBN 978-981-10-8681-6, Print ISBN 978-981-10-8680-9, April 26-27, 2018. Springer (scopus indexed)

[7] Suma M.R., Madhumathy P., "Design and Development of Data Security Enhancement Features Using IoT and Cloud Convergence", Journal of Design Engineering, Toronto, Canada, pp. 3391-3406, Vol. 2021, Issue 7, 2021.

[8] Mallavalli Raghavendra Suma, Perumal Madhumathy, "An optimal swift key generation and distribution for QKD", Scientific and technical journal of information technologies, mechanics and optics, Journal of Cyberlenika, Vol. 22, ISSN: 2226-1494, eISSN: 2500-0373, Issue 1, pp. 101-113, 2022. (Scopus Indexed Journal).

[9] M.R. Suma, P. Madhumathy, "Brakerski-Gentry-Vaikuntanathan fully homomorphic encryption cryptography for privacy preserved data access in cloud assisted Internet of Things services using glow-worm swarm optimization", A Scopus Indexed Journal, Wiley, Transactions on Emerging Telecommunications Technologies, Research Article, Volume 33, Issue 12, December 2022 https://doi.org/10.1002/ett.4641

[10] Suma M.R., et.al., "Method for preventing security violation in communication network of Internet of things (IoT) devices", International Classification : G06F21/30, No. of Pages : 26 No. of Claims : 5, The Patent Office Journal No. 02/2021 Dated 08/01/2021 1462, Patent Application No. 202031052588 A, Date of filing of Application : 3/12/2020 and Publication Date : 8/01/2021…… Indian Patent filed and Published.

[11] Shyamala C., Sneha K., Gayana B.E., Nisha M., Suma M.R., "An End to End Dehazing method using Deep learning", International Journal of Science and Engineering Development Research (IJSDR), International Peer Reviewed & Refereed Journals, Open Access Journal, ISSN Approved Journal No. 2455-2631, Impact factor 8.15, Unique Id : IJSDR2007003, volume 5, Issue 7, pp. 16-20, July 2020

[12] Suma M.R. & Dr. Madhumathy P., "Hybrid Cloud-Intra Domain Data Security and to Address the Issues of Interoperability", International Journal of recent technology and Engineering (IJRTE), ISSN: 2277-3878, Published By - Blue Eyes Intelligence Engineering & Sciences Publication, A Scopus Indexed Journal, Volume 8, Issue-1, pp. 340-344, June 2019.

[13] Suma M.R., "A unified big data analysis platform using HADOOP technology", International Journal of Engineering and Computer Science, ISSN: 2319.7242, volume 5, issue 2, pp. no. 20379-20382, Feb 2017, Index Copernicus Value (2015): 58.10, DOI:10.18535/ijece/v6i2.38.

[14] Suma, M.R., Madhumathy, P., "Acquisition and Mining of Agricultural Data Using Ubiquitous Sensors with Internet of Things", Springer International Conference on 166 Computer Networks and Communication Technologies (Scopus Indexed Conference), vol. 15, pp. 249–261, 2018 https://doi.org/10.1007/978-981-10-8681-6_24

[15] BGV-FHE Cryptography for Privacy Preserved Data Access in Cloud Assisted IoT Services Using GSO Optimization", Scientific & Technical Journal of Information Technologies, Mechanics and Optics, Vol. 22, No. 1, ISSN 2226-1494 (print), pp. 101-113, January–February 2022.

[16] Dr. Suma M.R., Sanjana Prasanna, Dr. T.C.Manjunath, "A Review of IoT Networking Threats and Vulnerability Analysis, Identification, Detection, and Mitigation in Communication Systems", Tuijin Jishu / Journal of Propulsion Technology, ISSN: 1001-4055, Indexed by Elsevier Scopus, SCI Q3, SJR 2022 – 0.32, SNIP 2022 1.069, H-Index 24, CiteScore 2022 1.1, DOI : 10.52783/tjjpt.v44.i4.1843, Vol. 44, Issue 4, pp. 5069-5074, Oct-Dec. 2023.

[17] Suma M.R. & et.al., Acquisition & Mining of Agricultural Data using Ubiquitous Sensors with Internet of Things" presented a paper in International Conference on Computer Networks and Inventive Communication Technologies, International conference on computer networks and communication Technologies (ICCNCT 2018) April 26-27, 2018, Coimbatore, INDIA. Published in Lecture notes on Data Engineering and Communications Technologies, Springer Publication
[18] Suma M.R. & et.al., Hybrid Cloud-Intra Domain Data Security and to Address the Issues of Interoperability" International Journal of recent Tech. & Engg. (IJRTE)ISSN: 2277-3878, Volume 8, Issue-1, Jun. 2019.
[19] Y. Ambika Naik, M.R. Suma, P Madhumathy "Air Quality Monitoring System Through Mobile Sensing in Metropolitan City" ICICI 2018, International Conference on Intelligent Data Communication Technologies and Internet of Things Confyy on 7th and 8th August 2018 at Coimbatore, Tamil Nadu, India
[20] Suma M.R., Dr. Madhumathy P, "Hybrid Cloud Intradomain data security and address the issue of Interoperability" SITAMS International Conference on Innovation in Engineering, Technology and Science, SICIETS, 2018, Chittoor, Andhra Pradesh, Oct 28-29, 2018
[21] Suma M.R. & et.al., Optimization in fault tolerant topology control process for multihop networks, National Conference on Convergence of Science, Technology & Management at Dayananda Sagar Academy of Technology and Management, Bangalore. 5th May 2016.
[22] Suma M.R. & et.al., A unified big data analysis platform using HADOOP technology" International Journal of Engineering and computer science, ISSN: 2319.7242, volume 5, issue 2, Feb 2017, pp. 20379-20382, DOI:10.18535/ijece/v6i2.38.
[23] Suma M.R. & et.al., Analysis of sense amplifier circuits in different nanometer technology" presented a paper in 4th International Conference on Signal Processing, Communications and Networking (ICSCN -2017), March 16 – 18, 2017, Chennai, India