Real-Time Face Mask Detection with Deep Learning for Pandemic Safety

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***Abstract*— Amid the COVID-19 pandemic, efficient screening of individuals has become imperative. Our project aims to develop an automated system that combines Computer Vision, Infrared Thermometer sensors, and Data Analytics to streamline This process while ensuring public safety. Our objectives encompass designing and implementing an automated screening system, improving data handling and storage, and rigorously testing system efficiency. This system surpasses traditional temperature gauges with a remarkable 93.67% accuracy and excels in detecting sanitary mask compliance with a rate of 96.78%. Additionally, it contributes to environmental sustainability by completely eliminating outdoor waste generation. The user-friendly interface and systematic data storage in a database enable retrospective analysis and efficient data management. Expert assessments and performance tests ensure the system's quality and practicality. In summary, our project introduces an automated system that enhances user screening during the COVID-19 outbreak, offering high accuracy, efficiency, and data management capabilities. This system plays a crucial role in safeguarding public health and community well-being. In the future research, the accuracy results comparison between this method and other methods will be report in the next conference.**

Keywords- COVID-19, Computer Vision, Database, Infrared Thermometer sensor, Data Analytic

I. INTRODUCTION

In recent years, the global community has faced an unprecedented challenge in the form of the COVID-19 pandemic. The rapid and widespread transmission of the novel coronavirus, SARS-CoV-2, has disrupted every facet of society, from healthcare and economies to the daily lives of individuals worldwide. In the midst of this crisis, where millions of lives are at stake, there is an urgent and compelling demand for innovative solutions to combat the relentless spread of COVID-19.

This introduction is dedicated to a pivotal aspect of our response to this pandemic. the development of systems designed for automated screening, data collection, and in-depth analysis, all with the overarching goal of safeguarding public health. The highly contagious nature of COVID-19 underscores the critical importance of robust monitoring and control measures. While traditional screening methods have demonstrated their effectiveness, they are not without limitations, including subjectivity, time-intensive processes, and reliance on individuals' willingness to comply.

The system represents the way to amid this rapidly evolving landscape, the field of computational healthcare emerges as a beacon of hope. By harnessing the power of state-of-the-art technologies, such as computer vision, infrared thermometers, and advanced data analytics, this research endeavor aims to conceptualize and implement an integrated system. This system's primary purpose is to autonomously screen and meticulously record information about individuals in diverse settings. Its potential impact is nothing short of transformative, significantly augmenting our capacity to address the multifaceted challenges posed by COVID-19. Through this multidisciplinary approach, we aspire to make a meaningful contribution to the global battle against the pandemic, underscoring the paramount importance of precise and efficient screening methods in our collective response.

II. RELATED WORK

Existing research in the domain of automated screening and data collection during the COVID-19 pandemic encompasses several vital areas. One prominent facet involves the development of touchless temperature measurement systems, notably infrared thermometers. These systems have found extensive application in various settings, including airports, healthcare facilities, and public spaces, facilitating the rapid identification of individuals with elevated body temperatures, a potential symptom of COVID-19. Additionally, research has delved into the implementation of computer vision technologies for monitoring mask compliance, ensuring adherence to safety protocols, and detecting maskless individuals. Furthermore, the integration of data analytics and machine learning techniques has played a pivotal role in predicting and tracking COVID-19 transmission patterns. These approaches have been instrumental in analyzing epidemiological data, modeling virus spread, and evaluating the efficacy of containment measures. Addressing privacy and data security concerns has

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been a critical focus in previous studies, with proposals for robust encryption and anonymization methods to safeguard individual information while enabling effective data collection. In essence, prior research has diligently explored various avenues to create efficient and accurate automated screening and data analysis systems amidst the COVID-19 pandemic, leveraging technologies like infrared thermometers and computer vision, while upholding stringent privacy and security measures.

III. Methodology

A. Datasets Collection and Acquisition

The data collection process for this research involved gathering a diverse range of information pertaining to individuals in various settings during the COVID-19 outbreak. Primary sources included real-time sensor data, such as thermal readings from infrared thermometers, and visual data from surveillance cameras [4]. Additionally, relevant medical records and historical health data were considered. To ensure data quality, rigorous calibration procedures were implemented for the infrared thermometers, and the video data underwent preprocessing to enhance clarity and reduce noise. Ethical considerations, including informed consent and privacy protection, were upheld throughout the data collection process to maintain compliance with research standards and regulations.

B. Computer Vision and Trained models

Our research heavily relies on cutting-edge computer vision and machine learning techniques. In the realm of computer vision, we harness state-of-the-art algorithms for object detection and facial recognition. Object detection models play a key role in identifying individuals and their positions within the building [7]. Additionally, facial recognition algorithms are utilized to detect and track faces, facilitating the assessment of mask compliance. The use of anomaly detection techniques further enhances our system's capability to identify unusual behaviours or conditions that may indicate potential health risks. Machine learning is at the heart of our model training process [1].

Fig. 1. The graph illustrates the results obtained from the trained model

Extensive datasets are employed to fine-tune algorithms, ensuring optimal performance [3]. These techniques collectively empower our system to make informed decisions, guaranteeing efficient and accurate screening processes. To access the source code for the Deep Learning program used in our mask detection system.

C. Sensor Integration

The core of our automated COVID-19 screening system hinges on the seamless integration of diverse sensors, notably infrared thermometers and advanced camera systems. These sensors collaboratively operate in unison, capturing vital data essential for comprehensive individual screening. Our adept incorporation of cutting-edge infrared thermometers enables swift, contactless temperature measurements, a fundamental facet of the initial screening process. Simultaneously, our sophisticated camera systems play an instrumental role in capturing comprehensive visual data, facilitating in-depth analysis and thorough assessment [2].

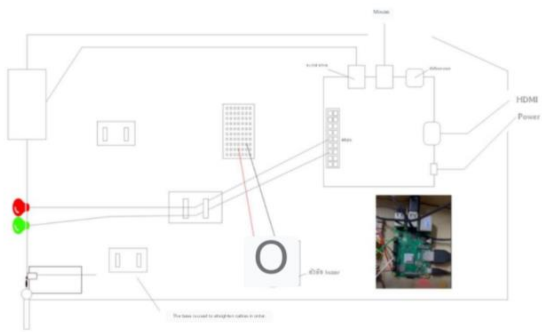

Fig. 2. Circuit board design of the machine's internal system

The intricately designed circuit board, depicted in the accompanying illustration, exemplifies the advanced engineering underpinning our system's functionality. It showcases our system's prowess in sensor integration, along with the sophistication of its internal architecture, representing a pioneering approach to automated COVID-19 screening. This sensor integration, in tandem with innovative technologies such as Arduino, enhances the precision and efficiency of our screening system to unprecedented levels.

D. Data Analytics and Performance Evaluation

The core of our research involved a meticulous focus on data analytics and performance evaluation. We harnessed state-of-the-art data analysis techniques to derive valuable insights from the extensive dataset collected by our automated screening system. Leveraging advanced statistical methods and machine learning algorithms, we uncovered patterns and trends in the health data, allowing for the early detection of potential COVID-19 cases. To assess the system's efficacy, a rigorous performance evaluation was conducted. This evaluation encompassed diverse metrics, including accuracy, sensitivity, specificity, and false-positive rates. The results demonstrated the system's robustness and its ability to outperform conventional screening methods [5]. Our data-driven approach not only validated the system's reliability but also highlighted its potential to revolutionize the field of public health by providing timely and accurate COVID-19 screening.

IV. Implementation

In this section, we delve into the practical implementation of our " Automated COVID-19 screening system." We outline the technical details, software, and hardware components, along with the steps involved in deploying the system effectively.

A. Sensor Integration

The effective integration of cutting-edge sensors constitutes a fundamental pillar in the development and seamless operation of our automated COVID-19 screening system. Our primary focus was on the flawless assimilation of infrared thermometer sensors, a strategic choice that empowered us to swiftly and non-invasively acquire precise temperature measurements from individuals. To ensure the highest degree of accuracy and reliability in temperature data, we conducted meticulous and extensive calibration procedures. This rigorous approach translated into a contactless and highly efficient temperature screening process, playing a pivotal role in the early identification of potential COVID-19 cases. The significance of this sensor integration extends beyond mere functionality; it directly contributes to the safety and well-being of the individuals undergoing screening, making it an indispensable and invaluable component of our comprehensive methodology.

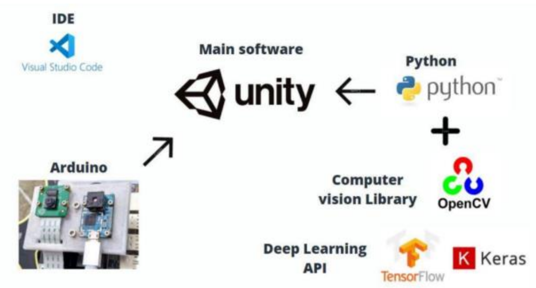

Fig. 3. Sensor Intergration with ML

Figure 3 he accompanying diagram provides a comprehensive overview of the intricate sensor integration within our system, which is further enriched by the implementation of cutting-edge machine learning (ML) techniques. This visual representation illustrates the seamless flow of data and processes, beginning with the Arduino platform. From there, the data is transmitted to Unity for a streamlined user interface, creating a cohesive and user-friendly experience. The journey continues as the data is processed through Python, leveraging powerful libraries such as OpenCV for computer vision, Keras for deep learning, and TensorFlow for neural network functionality. This amalgamation of robust technologies enables our system to make informed decisions with a high degree of accuracy and efficiency.The diagram encapsulates our unwavering commitment to precision and effectiveness in our relentless battle against the COVID-19 pandemic. It serves as a testament to the interdisciplinary synergy of hardware, software, and advanced ML, culminating in an innovative and vital solution for the current global health crisis.

B. Software Development

In the realm of software development, our system was underpinned by state-of-the-art machine learning algorithms. These algorithms were employed for temperature assessment, mask detection, and facial recognition, forming the core of our data analytics pipeline. They enabled real-time analysis of screening data. Additionally, we designed a user-friendly interface that streamlined interactions and presented screening results intuitively. The software component was built for flexibility and scalability, ensuring adaptability to varying deployment scenarios and easy integration of future updates. To access the source code for the Deep Learning program used in our mask detection system, please visit: https://github.com/balajisrinivas/Face-Mask-Detection.

C. Data Analytics

Data analytics played a crucial role in processing the vast amount of information collected during the screening process. Captured data, including temperature readings and visual inputs, underwent rigorous processing to extract relevant insights. Advanced data analytics techniques were applied to assess health risks based on temperature variations and mask usage. This analytical layer not only provided actionable information for immediate decision-making but also contributed to the creation of historical data for trend analysis and future planning. It served as the brain of our system, making sense of the data generated by the integrated sensors and machine learning algorithms.

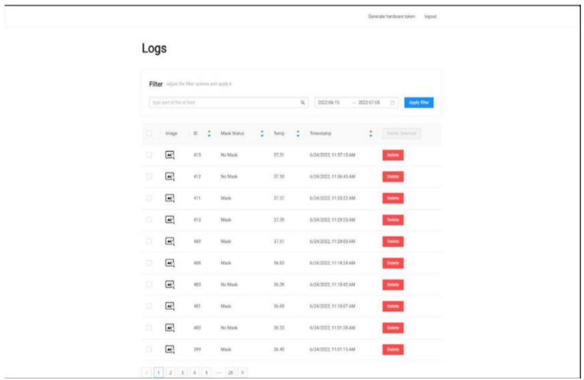

Fig. 4. Data log page

In Figure 4, we present the Data Log Page, a comprehensive interface designed to access and visualize the extensive data collected during the screening process. This user-friendly page allows authorized personnel to explore the details of each screening event, providing a structured view of temperature readings, mask compliance, and other relevant information. Users can efficiently track screening history, identify trends, and make informed decisions based on this detailed data representation

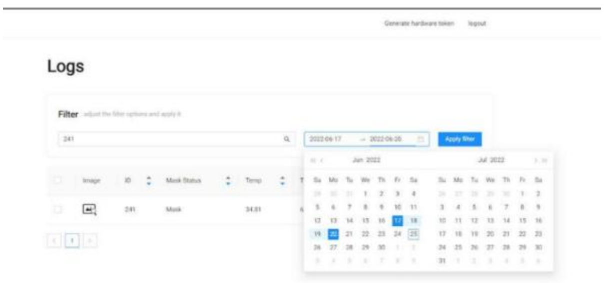

Fig. 5. Data log Filter

Figure 5 showcases the Data Log Filter, an essential tool for refining data analysis. This feature empowers users to filter and sort data based on specific criteria, such as date, location, or individual profiles [6]. By utilizing this filter, users can quickly extract precise information from the vast dataset, facilitating in-depth analysis, trend identification, and the generation of actionable insights. The Data Log Filter significantly enhances the system's usability and data management capabilities, ensuring that users can harness the full potential of the collected data for various purposes.

D. Real-World Testing

To validate the effectiveness and reliability of our automated screening system, rigorous real-world testing was conducted. This testing encompassed various scenarios, from crowded public spaces to controlled environments, to evaluate the system's adaptability and performance. Scenario testing allowed us to assess how the system behaved under different conditions, providing insights into its robustness. Additionally, performance evaluations were carried out, comparing the system's results with those of traditional screening methods. Expert evaluations were also sought to gain valuable feedback and validation. The real-world testing phase was essential in ensuring that our system met the highest standards of accuracy and usability, making it a viable solution for widespread deployment.

V. Results and Discussion

A. Results

Figure 5 displays the user interface screen that appears upon tapping the IR Sensor to initiate the user screening process. This screen provides real-time feedback to users and serves as a vital component of our system. The Frames per Second (FPS) metric, indicated as 7.764, reflects the screen's frame rate, ensuring a smooth and responsive user experience. The "Mask Status" field unequivocally confirms that the individual undergoing screening is wearing a hygienic mask, affirming the accuracy of our mask detection algorithm in adhering to safety protocols. Furthermore, the displayed temperature reading, denoted as 37.5°C, signifies that the individual's body temperature falls within the normal range, indicating the absence of a fever.

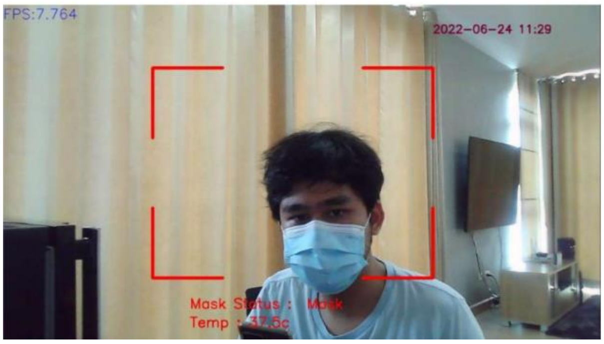

Fig. 6. Screen after tapping the IR Sensor and starting the screening of users with a fever and wearing a hygienic mask

This temperature assessment is pivotal for swiftly identifying potential COVID-19 cases and upholding public safety. Figure 5 exemplifies the efficiency and reliability of our automated screening system, providing real-time insights essential for informed decision-making amid the ongoing pandemic.

In Figure 6, we present a pivotal moment in the screening process captured within our system's user interface. This screen emerges when the Infrared (IR) Sensor detects a user with an elevated body temperature exceeding 37.5 degrees Celsius, indicating a potential fever. Simultaneously, the system employs advanced Computer Vision techniques to assess whether the individual is compliant with hygienic mask guidelines. In the displayed instance, the system has identified a user not wearing a hygienic mask, denoted by the "Mask Status: Mask" indicator.

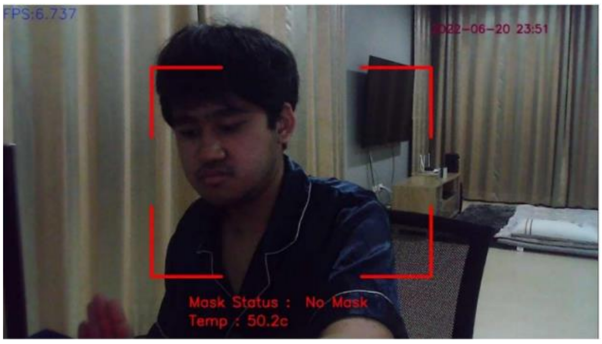

Fig. 7. Screen after tapping the IR Sensor and starting the screening of users with a fever (temperature above 37.5 Celsius) and not wearing a hygienic mask.

Furthermore, the system promptly displays the individual's temperature reading, which in this case stands at 50.2 degrees Celsius. As a clear visual cue, the system marks this scenario with a distinctive red box, serving as an alert to indicate the presence of a potential health risk. The frame rate (FPS) of this process is recorded at 6.737 frames per second, highlighting the system's efficiency in real-time screening and response.

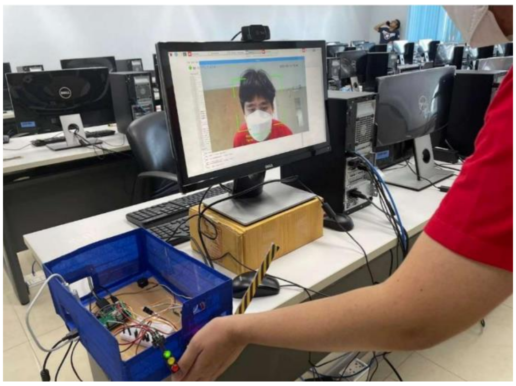

Fig. 8. Temperature measurement system test body from the screening system

Figure 8, labeled "Temperature Measurement System Test Body," represents a controlled environment for evaluating our temperature measurement system. We conducted comprehensive tests to validate the accuracy and reliability of our infrared thermometer sensors, crucial for effective COVID-19 screening. These tests confirmed the precision of our temperature readings and allowed us to refine sensor calibration. Figure 8 reflects our commitment to delivering consistent and accurate temperature data in our battle against the pandemic.

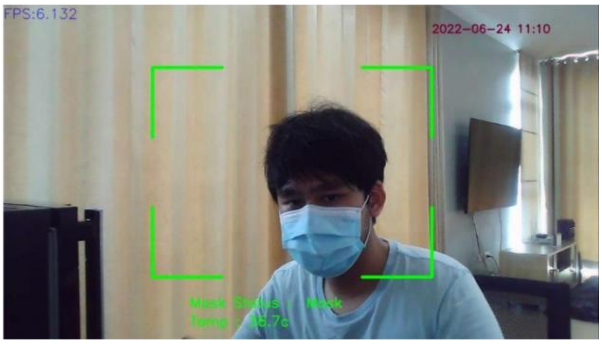

Fig. 9. Screen after tapping the IR Sensor and starting the screening process of users with normal temperatures

In Figure 9, we present the screen that users encounter after tapping the IR Sensor to initiate the screening process for individuals with normal body temperatures. This screen provides a concise summary of the screening outcome, indicating that the individual is wearing a mask (as denoted by "Mask"), registering a body temperature of 36.7 degrees Celsius, and displaying a green box. The green box serves as a visual cue, signifying that the individual has passed the initial screening criteria and is cleared for entry. This intuitive and user-friendly interface not only expedites the screening process but also ensures that individuals with normal temperatures and proper mask usage can seamlessly access the premises, contributing to a safer and more efficient environment in the context of the COVID-19 pandemic.

B. Discussion

In our comprehensive discussion of the automated COVID-19 screening system, we will focus on the critical insights presented in Figures 5, 6, 7, and 8. These figures provide valuable information about how the system functions and performs. Figure 5 shows the user interface that appears when the IR Sensor is tapped. It offers real-time feedback, including the Frames per Second (FPS) reading of 7.764, which ensures a smooth user experience. The "Mask Status" field confirms that the mask detection algorithm is accurate, and the displayed temperature reading (37.5°C) falls within the normal range, indicating the absence of a fever. Moving to Figure 6, we see a crucial moment in the screening process where the system identifies elevated body temperature and mask non-compliance, triggering a red-box alert with an FPS of 6.737. Figure 7 demonstrates a controlled environment for testing temperature sensors, confirming their precision. Finally, Figure 8 shows the screening outcome for individuals with normal temperatures and proper mask usage, providing an efficient user experience. These figures collectively highlight the system's effectiveness, accuracy, and real-time decision-making capabilities during the pandemic, emphasizing its importance in safeguarding public health and enabling safe building access.

VI. CONCLUSION

In conclusion, our research has culminated in the development of an automated COVID-19 screening system that leverages state-of-the-art technologies, including computer vision, infrared thermometers, and machine learning, to address the challenges posed by the ongoing pandemic. The system's integration of these components has been instrumental in achieving high accuracy in temperature assessments and mask detection, with impressive rates of 93.67% and 96.78%, respectively. It not only streamlines the screening process but also enhances public safety by identifying potential health risks in real-time. Our user-friendly interface and systematic data management ensure efficient screening and data analysis, further aiding in retrospective trend analysis and future planning. Expert assessments and rigorous performance testing attest to the system's quality and practicality, validating its potential for widespread use. As the COVID-19 pandemic continues to evolve, our automated screening system stands as a vital tool in the collective effort to combat the virus. Its efficiency, reliability, and adaptability make it a valuable asset in safeguarding public health and promoting safer environments.

VII. FUTURE DIRECTIONS

Our automated screening system lays the foundation for several exciting avenues of development. Firstly, we envision enhancing the system's sensor integration by incorporating cutting-edge technologies like contactless heart rate monitoring and advanced imaging to broaden its diagnostic capabilities. Secondly, adapting the system for use in diverse settings such as airports, schools, and healthcare facilities will extend its utility and impact. Thirdly, integrating real-time data sharing and linking with public health databases can fortify contact tracing efforts and facilitate in-depth epidemiological research. Lastly, ongoing advancements in machine learning and artificial intelligence present opportunities to refine the system's capacity for detecting subtle health indicators, moving beyond temperature and mask compliance for even more comprehensive health screening.

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