**Artificial Intelligence Based Appointment Allocation and Doctor Availability Management System**

**Dibyendu Deb, Sougata Maity**

*Department of Computer Science Engineering, Brainware university, Kolkata, India*

**Abstract:** Hospital appointment scheduling is a difficult and complicated issue that has an impact on the effectiveness and standard of healthcare delivery. Optimizing doctor availability and patient appointment slot distribution, while reducing wait times and raising patient satisfaction, is one of the primary goals of appointment scheduling. However, a variety of issues can impact this process, including the erratic nature of patient demand, the preferences and limitations of both parties, and the ambiguity surrounding the presence of a doctor. In this paper, we propose an AI-powered web platform designed to enhance hospital appointment scheduling. By maximizing the use of physician resources, decreasing patient wait times and no-show rates, and fostering greater mutual trust and satisfaction, we think our approach can improve the hospital appointment scheduling process.

**Keywords:** Artificial Intelligence, Machine Learning, Hospital Management, Automation, Healthcare.

**INTRODUCTION**

Ineffective appointment scheduling is a major issue in the healthcare industry since it affects the efficiency and quality of medical services rendered. Long wait times, low patient satisfaction, and underutilization of resources are issues that many hospitals deal with because of the unpredictability of doctor availability, the fluctuation of patient demand, and the difficulty of scheduling appointments. The solution puts forth a novel approach that makes use of artificial intelligence (AI) to streamline the online platform's appointment-booking procedure. In order to prioritize and assign appointments to patients based on pre-established criteria, our system makes use of facial recognition technology to confirm doctors' presence in real time. In addition, our system offers a digital interface that is easy to use for patients to make, modify, or cancel appointments online, as well as get reminders and notifications on their visits. The Artificial Intelligence (AI) module makes the final choice after the system gathers data from the patients, verifies the doctor's availability, and generates a list of confirmed appointments. Here, the AI module applies human brain logics as predefined parameters. The system offers automation in healthcare appointment scheduling and bypasses the regular, manual, and time-consuming processes.

**LITERATURE REVIEW**

The enhancement of patient care and operational efficiency in the healthcare industry heavily depends on optimizing doctor availability and appointment scheduling. Issues with inefficient use of resources and dissatisfied patients are common to traditional appointment systems. This study of the literature looks at the research that has already been done on facial recognition software, AI integration in healthcare, and appointment scheduling systems.

Several research works have examined the drawbacks of conventional systems for booking appointments. **[1]** Elizabeth, Aditi Sen, W. Woodcock's research from (2022) brought attention to the inefficiencies that result from manual scheduling procedures, which lengthen patient wait times and underuse medical personnel.

**[2]** Bohr, Adam, and Kaveh Memarzadeh (2020) have examined the transition to digital appointment systems, highlighting the need for more advanced technologies to handle the dynamic nature of healthcare environments. In healthcare administration, artificial intelligence (AI) has emerged as a game-changing instrument. Recent research **[3]** (J. Guo, B. Li, 2018) indicates that artificial intelligence (AI) can improve patient outcomes, optimize resource allocation, and increase the overall efficiency of healthcare systems. By integrating AI into appointment scheduling processes to support customized and adaptable solutions, a more patient-centric approach may be achieved.

In the healthcare sector, face recognition technology is growing in popularity, particularly for monitoring the presence of physicians. **[4]** Hasan, Ramadan TH, and Amira Bibo Sallow’s research from 2021 showed that facial recognition systems based on OpenCV are accurate and practical for use in identifying and authenticating medical staff. **[5]** Suman Jana, Arvind Narayanan, and Vitaly Shmatikov's work (2013) emphasizes that resolving privacy and security vulnerabilities is necessary before implementing such technologies.

The reviewed literature highlights the need for a thorough approach to arranging medical appointments. Together, face recognition technology and AI-powered algorithms present an opportunity to create a dynamic, adaptable system that increases patient happiness while optimizing physician availability. Furthermore, recent studies highlight how important it is to take several aspects into account in order to increase the accuracy and flexibility of appointment scheduling systems.

In summary, by highlighting knowledge gaps and highlighting the potential for combining AI with facial recognition technology to radically alter hospital appointment scheduling, this review of the literature establishes the foundation for the proposed study.

**METHODOLOGY**

In this section, we outline the technology tools and research techniques. We describe how we incorporated OpenCV for facial recognition to track hospital physician attendance and how we used a generative AI model to assign patient appointments based on numerous criteria. We also discuss the development and implementation of our web-based platform, which functions as the user interface for our system.

***i)* Face recognition:**

Using OpenCV, an open-source computer vision framework, we developed our system's facial recognition feature. The Haar Cascade classifier was used to recognize the doctors' faces in the images captured by the hospital's cameras. Once the FaceNet model had extracted the facial embeddings of the recognized faces, we compared these to the registered physician embeddings stored in our database. The degree of similarity between the embeddings was evaluated using the cosine similarity metric, and a threshold was set to determine whether the faces matched. We updated the doctors' availability status and retained them in our database based on the facial recognition results.

***ii)*Appointment allocation**:

We used a generative AI model to prioritize and assign patients to appointments based on first come, first served, patient history, distance from home to hospital, and appointment type. A recurrent neural network (RNN) was used to create the appointment schedules for each doctor, considering the number and priority of patients on waitlists, the preferences and limitations of both parties, and the availability status. A reinforcement learning (RL) technique was used to train the RNN model, and waiting time and patient satisfaction were used to fine-tune the reward function.

***iii)*User Interface**:

We developed an interface for our system on a web-based platform. We used Flask and Python for back-end development, and HTML, CSS, and JavaScript for front-end development. We used Firebase for notification services and authentication, and MongoDB for database administration. Patients can schedule, change, or cancel appointments online with our platform and receive notifications and reminders for their appointments. The doctors can also check, manage, and manually change their availability status as needed.

A screenshot of a medical application

Description automatically generated

**Figure 1:** Web-interface

**FACE RECOGNITION SYSTEM**

This section describes the usage of OpenCV for real-time facial recognition and the hospital's doctor presence checker system. We also stress the need of security and privacy protections for face recognition and how our system manages these.

1. **Implementation of OpenCV**:

Our system's facial recognition capability was implemented using OpenCV, an open-source computer vision framework. For face analysis, face recognition, and face detection, OpenCV offers a variety of modules and features. The facial recognition feature was implemented using the following steps.:

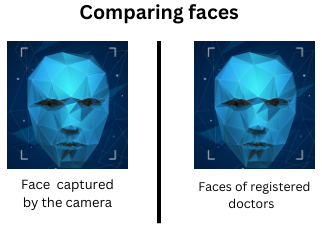
* 1. **Face detection**: In the pictures taken by the hospital's cameras, we were able to identify the faces of the doctors using the pre-trained object detection model known as the Haar Cascade classifier. The Haar Cascade classifier employs a sequence of filters to remove false positives after identifying the regions of interest in the images using a cascade of basic features. A collection of bounding boxes containing the identified faces is the result of this stage.

A person holding a fishing rod

Description automatically generated

**Figure 2:** Face detection of the doctor

* 1. **Face recognition**: We extracted the facial embeddings of the identified faces using a deep neural network model called FaceNet. The FaceNet model uses a high-dimensional feature space to map the faces, and the similarity between the faces is represented by the distance between their embeddings. The cosine similarity metric was utilized to gauge how close the embeddings of the discovered faces were to those of the registered doctors that were kept in our database. Based on the outcomes of the facial recognition, we updated the doctors' availability status and set a threshold to see if the faces matched.



**Figure 3:** Recognizing the face

* 1. **Face analysis**: For face analysis on the identified faces, we used the Dlib library, a machine learning and computer vision toolkit. The facial landmarks, such as the mouth, nose, eyes, and chin, were located using the Dlib's shape predictor. The faces were then aligned and cropped using the Dlib's face alignment feature. Additionally, we computed the facial descriptors—vectors that capture the aspects of the face—using the Dlib's face descriptor. Face verification, face clustering, and face recognition were accomplished with the help of these descriptors.

**ALGORITHM 1: FACE DETECTION OF DOCTOR’S**

***1:*** *Import Libraries:*

*//Import necessary libraries like OpenCV, NumPy.*

***2****: Load Haar Cascade Classifier:*

*//Load the pre-trained Haar Cascade classifier for face detection.*

*3****:*** *Capture Video Stream:*

*//Access the video stream using the webcam or load a video file.*

***4:*** *Face Detection Loop:*

***5:*** *while True do*

***6:*** *Read a frame from the video stream.*

***7:*** *Convert the frame to grayscale for better processing.*

***8:*** *Use the Haar Cascade classifier to detect faces in the frame.*

***9:*** *if faces are detected then*

***10:*** *Check if the detected face matches the doctor’s face.*

***11:*** *if it matches then*

***12:*** *Check the doctor’s availability by predefined criteria.*

***13:*** *Display availability status on the screen or take specific*

*actions based on availability.*

***14:*** *end if*

***15:*** *end if*

***16:*** *end while*

***17:*** *Display Output:*

*//Show the video stream with detection results and availability status.*

***18:*** *Release Resources:*

*//Release the video stream and any allocated resources after processing.*

1. **Doctor’s presence verification:**

By using the facial recognition technology, we were able to update the doctors' availability status in real time and confirm their presence within the hospital. The hospital's entrance and exit, as well as common spaces like the cafeteria, waiting room, and halls, all have cameras installed. The doctors' photos were taken at regular intervals, and the facial recognition feature was used to process them. The doctors' availability status was entered into our database and utilized to create patient appointment calendars. Additionally, we put in place a facial recognition verification system that lets the doctors use their smartphones to verify their identification and availability.

**SECURITY AND PRIVACY MEASURES**

We have taken security and privacy safeguards into consideration in our system since we understand how important they are for face recognition. To protect the security and privacy of the face recognition feature, we take the following precautions :

* 1. **Encryption:** A strong encryption algorithm, like AES or ChaCha20, is used to encrypt the photos and the facial embeddings of the patients and the physicians. We keep the encrypted information in our database and only decode it when facial recognition calls for it. Also, the data that is transferred back and forth between the cameras, mobile devices, and database is encrypted using a secure encryption standard like SSL or TLS.
  2. **Authentication:** Our multi-factor authentication technique is used to confirm the patients' and doctors' identities. To obtain entry into the system, individuals need to provide their login credentials, password, and face scan. In addition, we verify the authenticity and integrity of the cameras and cellphones through the use of a digital signature method.
  3. **Authorization**: We only give the physicians and patients permission to view the information and tools that are pertinent to and required for them. Additionally, we give the cameras and cell phones permission to use the facial recognition capability exclusively—all other system features are off limits.
  4. **Consent:** Before gathering and using the patients' facial data, we get permission from both the physicians and the patients. We let customers know about the face recognition feature's objectives, limitations, and duration as well as the security and privacy precautions we take. They can always choose not to have their face data shared with us or remove it.

**AI MODULE FOR APPOINTMENT ALLOCATION**

Here, we go over the AI module that we utilized to prioritize and schedule patient visits using the pre-trained criteria. Additionally, we describe the decision-making procedure used to assign appointments as well as how the system adjusts and gains knowledge from fresh data to increase the accuracy of appointment scheduling.

* + 1. **Training process**: The amount and priority of patients on waitlists, the preferences and limits of both parties, and the availability status were all taken into consideration while creating the appointment schedules for each doctor using a recurrent neural network (RNN). The RNN model was trained using a reinforcement learning (RL) algorithm, and the reward function was then tuned according to patient satisfaction and waiting time. The RNN model was initialized with pre-trained parameters from earlier research and data, then we adjusted them with our own data and user feedback.
    2. **Decision-making process**: The appointment calendars for each doctor were created using the RNN model, and the optimal schedule was chosen for each doctor using the softmax function. Based on the reward function, the softmax function assigns a probability to each schedule and selects the schedule with the highest likelihood. The following factors are considered by the reward function: first come-first served and the distance between the patient's home and the hospital.

1. **First come-first served factor:** The AI module will be assigned a predefined number of the maximum appointments the doctor can accept. Applications for appointments will have their names added to a queue. The names will then be released based on a first-in, first-out function from that list of names. Those who applied earlier will receive an appointment that has been confirmed.

Enqueue

PATIENT 4

PATIENT 2

PATIENT 3

PATIENT 1

Dequeue

**Figure 4:** Appointment request stored in queue

1. **Distance between the patient's home and the hospital:** The system uses geocoding API to get the latitude and longitude coordinates of the patient’s address and the hospital’s address. In the next step it uses Haversine formula to calculate the distance between the patient’s home and the hospital.

Given:

lon1, lon2 = longitude values of two points

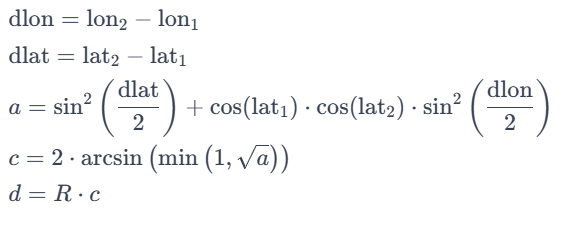
lat1, lat2 = latitude values of two points

R = radius of the Earth (or the sphere being measured)

Calculations:

A math equations on a white background

Description automatically generated



Where:

dlon = Difference in longitudes

dlat = Difference in latitudes

a = Intermediate calculation for distance calculation

c = Angular distance in radians

d = Distance between two points on the Earth's surface

The schedules that reduce waiting times and increase patient happiness are given a greater value by the reward function, whereas those that go against the doctors' or patients' wishes and limitations are given a lower value.

**ALGORITHM 2: PRIORITIZING PATIENT APPOINTMENTS**

***1****: function PrioritizeAppointments(patientList)*

***2****: Input: List of patients with their details*

***3****: Output: Sorted list of patients based on priority for appointment*

***4****: Initialize a priority queue or sorting mechanism based on parameters*

***5****: for each patient in patientList do*

***6****: Calculate a priority score for the patient based on defined parameters*

***7****: Assign weightage to each parameter based on its importance*

***8****: Calculate a combined priority score using these weights and patient details*

***9****: end for*

***10****: Sort patients based on their calculated priority scores*

***11****: Return the sorted list of patients*

***12****: end function*

***13****: function UsageOfSortedList(sortedList)*

***14****: Usage of the sorted list for appointment allocation*

***15****: Patients at the top get earliest appointment slots based on priority*

* + 1. **Adaptation and learning**: We implemented a feedback system that lets patients assess their encounter and offer recommendations for enhancements. We updated the RNN model and the reward function using this feedback, which also increased the accuracy of the appointment allocation. Additionally, we made use of a system for gathering and analyzing data from web-based platform features, appointment scheduling, and face recognition. With the use of this data, we were able to increase the appointment allocation efficiency and update the RNN model and pre-trained parameters.

**WEB PLATFORM INTEGRATION**

This part covers the construction and integration of the web platform that serves as our system's interface. We concentrate on the elements that facilitate online appointment scheduling for patients and on the usability and accessibility of the platform.

1. **Development**: We used HTML, CSS, and JavaScript for the front-end development, and Python and Flask for the back-end development. To manage the database, we used MongoDB, and Firebase to provide notification and authentication resources. The online platform's facial recognition and appointment scheduling functions were integrated using the RESTful API, which also served as a communication channel between the front and back ends.

**ALGORITHM 3: PATIENT REGISTRATION AND LOGIN SYSTEM**

*1: procedure CheckRegistration*

*2: If Patient is Registered then*

*3: Prompt for login credentials (username/password).*

*4: Proceed to login.*

*5: Else*

*6: Prompt the user for registration or continue as a guest.*

*7: If user chooses registration then*

*8: Collect basic personal details: Name, Date of Birth, Email, Contact Number, Address, etc.*

*9: Generate a unique user ID (e.g., using a combination of name and DOB).*

*10: Generate an initial password based on provided details.*

*11: Save user details (ID, name, password, etc.) to the database.*

*12: Provide the user with their generated user ID and initial password.*

*13: end if*

*14: end if*

*15: end procedure*

*16: procedure LoginProcess*

*17: Prompt the user for their user ID and password.*

*18: Verify the credentials with the stored information in the database.*

*19: If credentials are correct then*

*20: Grant access to the system.*

*21: Provide an option to change the password after the first login.*

*22: Update the password in the database if changed.*

*23: end if*

*24: end procedure*

*25: procedure ChangePassword*

*26: Prompt the user to change their initial password.*

*27: Verify the old password for security.*

*28: Update the password in the database with the new one.*

*29: end procedure*

1. **User-friendly features**: We designed the web platform to be user-friendly and intuitive for the patients. Using our simple interface, patients could make, change, or cancel appointments online, as well as monitor the progress and specifics of their appointments. We also provided a chatbot function that lets users ask questions and submit help requests while interacting with our system in natural language. An email or SMS reminder system that reminds people of their appointments has been put in place.
2. **Accessibility and ease of use:** We ensured the accessibility and ease of use of the web platform for the patients. We additionally widened up the web platform while rendering it simple to operate for those with disabilities, especially those with disabilities like vision, hearing, or cognitive impairments. Following to the Web Content Accessibility Guidelines (WCAG), accessibility features such as the size of fonts, contrast, keyboard navigation, captions, and alternate text were implemented.

**BENEFITS**

In this part, we outline the benefits of our approach for patients, clinicians, and hospital administration. We emphasize the ways in which our system may benefit all parties involved and raise the standard and effectiveness of health care delivery.

1. **Reduced Patient Wait Times**: Our system's ability to shorten patient wait times and enhance their entire experience is one of its key advantages. Our solution can optimize the scheduling and resource allocation process while guaranteeing that patients receive timely and appropriate care by utilizing the face recognition and AI module characteristics. Additionally, our system can boost patients' trust and commitment to the institution while easing their anxiety and dissatisfaction.
2. **Increased Doctor Efficiency**: Our solution can also help doctors become more productive and efficient while also enhancing their work-life balance. Our solution can automate the verification and updating of the doctor availability status by utilizing face recognition and online platform technologies, hence removing the need for manual intervention and confirmation. Our system can improve physician scheduling and resource use by utilizing the AI module and telehealth features, which also allow physicians to treat patients remotely and individually.
3. **Improved Data-Driven Decision Making**: An further advantage of our system is that it may help hospital administration make better data-driven decisions and improve their performance evaluation and strategic planning. Our system can offer insights and recommendations from the AI analysis of the facial recognition, appointment scheduling, and web platform data by utilizing the data gathering and analysis functionalities. Our technology can assist hospital administration in monitoring and enhancing the effectiveness and quality of healthcare delivery, as well as in optimizing staffing, resource allocation, and service offerings.
4. **Enhanced Patient Engagement**: Finally, our approach can increase patient outcomes and retention while also increasing patient involvement and happiness. Our system can offer a comfortable and easy-to-use interface for patients to book appointments online and communicate with us using natural language by utilizing the web platform and chatbot functionalities. Our system can give patients real-time information and feedback, as well as inspire and assist them in their health journey, by utilizing the personalized care plan elements and the notification and reminder system.

**RESULTS AND DISCUSSION**

This section presents our research's findings and offers a comparison and discussion with the conventional appointment-making techniques. We assess the effectiveness of our facial recognition software and AI module and examine how they affect hospital appointment scheduling.

* 1. **Performance evaluation**: To assess the effectiveness of our AI module and facial recognition system, we conducted a user survey and a simulation study. The performance was evaluated using the following metrics: security, correctness, utilization, satisfaction, and waiting time. The outcomes of our approach were contrasted with those of more conventional appointment-booking techniques, like manual or online scheduling and phone or email confirmation. We discovered that our system worked better than the conventional approaches in terms of decreasing wait times, raising patient happiness, and improving the accuracy and use of medical resources. Additionally, we discovered that our system guarded the confidentiality and security of the appointment and facial data, as well as identified and stopped any tampering or illegal access.
  2. **Comparison and discussion**: We examined the benefits and drawbacks of each approach after comparing the results of our system with those of the conventional appointment-making techniques. We discovered that our system was superior to the conventional techniques in the following ways:
     1. It optimized the appointment allocation based on the quantity and priority of waitlisted patients, as well as the preferences and constraints of both parties, and enhanced the fairness and efficiency of the process.
     2. It automated the identification of doctor availability and the assignment of appointment slots, eliminating the need for human intervention and manual verification.
     3. The system offered patients an easy-to-use and practical online scheduling interface, along with the ability to get appointment reminders and notifications.
     4. It decreased the number of appointment cancellations and no-shows while also increasing mutual trust and satisfaction.

**CONCLUSION**

The goal of this study is to offer an AI-powered online platform that intends to improve the hospital appointment administration procedure. Our system consists of three main components: (1) an AI module that ranks and assigns appointments to patients based on pre-defined criteria; (2) a web platform that provides a convenient and user-friendly interface for patients to book their appointments online; and (3) a face recognition feature that verifies the presence of doctors in the hospital and updates their availability status in real time.

By employing a user survey and a simulation study, we evaluated the effectiveness and impact of our system and compared the outcomes to traditional appointment scheduling techniques. We've found that our method can improve patient happiness, cut down on waiting times, and improve the efficiency and accuracy of medical resources. We have also examined the system's limits and ethical and technological issues, and we have made some recommendations for potential fixes and future paths.

It’s is believe that the way our system is designed to improve doctor availability and hospital appointment scheduling is a potential approach. Through addressing the obstacles and guaranteeing the moral application, our system has the potential to revolutionize the provision of healthcare and provide benefits for physicians, patients, and hospital administration. Our approach has the potential to enhance patient outcomes, optimize resource distribution, and create a more effective healthcare system.

**REFERENCES :**

* 1. Woodcock, Elizabeth, Aditi Sen, and Jonathan Weiner. "Automated patient self-scheduling: case study." *Journal of the American Medical Informatics Association* 29.9 (2022): 1637-1641.
  2. Bohr, Adam, and Kaveh Memarzadeh, eds. *Artificial intelligence in healthcare*. Academic Press, 2020.
  3. Guo, Jonathan, and Bin Li. "The application of medical artificial intelligence technology in rural areas of developing countries." *Health equity* 2.1 (2018): 174-181.
  4. Hasan, Ramadan TH, and Amira Bibo Sallow. "Face Detection and Recognition Using OpenCV." *Journal of Soft Computing and Data Mining* 2.2 (2021): 86-97.
  5. Jana, S., Narayanan, A., & Shmatikov, V. (2013, May). A scanner darkly: Protecting user privacy from perceptual applications. In *2013 IEEE symposium on security and privacy* (pp. 349-363). IEEE.
  6. Li, J. P. O., Liu, H., Ting, D. S., Jeon, S., Chan, R. P., Kim, J. E., ... & Ting, D. S. (2021). Digital technology, tele-medicine and artificial intelligence in ophthalmology: A global perspective. *Progress in retinal and eye research*, *82*, 100900.
  7. Chowdhury, T., & Nilforooshan, R. (2021). ‘No more routine outpatient appointments in the NHS’: it is time to shift to data-driven appointment. *International Journal for Quality in Health Care*, *33*(1), mzaa150.
  8. Al-Turjman, F. (2023). Appointment System using Artificial Intelligence Techniques. *NEU Journal for Artificial Intelligence and Internet of Things*, *2*(2), 89-104.
  9. Dhopte, A., & Bagde, H. (2023). Smart smile: revolutionizing dentistry with artificial intelligence. *Cureus*, *15*(6).
  10. Vanaparthi, R., & Rao, S. V. A. (2023). REVOLUTIONIZING HEALTH CARE: AI-ENABLED DISEASE DIAGNOSIS, OUTCOME PREDICTION& OPERATIONAL EFFICIENCY. *Turkish Journal of Computer and Mathematics Education*, *14*(03), 993-1001.
  11. Chowdhury, T., & Nilforooshan, R. (2021). ‘No more routine outpatient appointments in the NHS’: it is time to shift to data-driven appointment. *International Journal for Quality in Health Care*, *33*(1), mzaa150.
  12. Tanjin, M., Osama, A. M., Barsha, J. B., Jowthi, C. B., & Pathak, A. STREAMLINING VISITOR APPOINTMENTS: AUTOMATED SCHEDULING SYSTEM FOR BGC TRUST UNIVERSITY BANGLADESH.
  13. Horvath, M., Levy, J., L'Engle, P., Carlson, B., Ahmad, A., & Ferranti, J. (2011). Impact of health portal enrollment with email reminders on adherence to clinic appointments: a pilot study. *Journal of medical Internet research*, *13*(2), e41.
  14. Horvath, M., Levy, J., L'Engle, P., Carlson, B., Ahmad, A., & Ferranti, J. (2011). Impact of health portal enrollment with email reminders on adherence to clinic appointments: a pilot study. *Journal of medical Internet research*, *13*(2), e41.
  15. Girard, B. (2009). *The Google way: How one company is revolutionizing management as we know it*. No Starch Press.
  16. Janett, R. S., & Yeracaris, P. P. (2020). Electronic Medical Records in the American Health System: challenges and lessons learned. *Ciencia & saude coletiva*, *25*, 1293-1304.
  17. Olivero, E., Bert, F., Thomas, R., Scarmozzino, A., Raciti, I. M., Gualano, M. R., & Siliquini, R. (2019). E-tools for hospital management: an overview of smartphone applications for health professionals. *International Journal of Medical Informatics*, *124*, 58-67.
  18. Emami, S., & Suciu, V. P. (2012). Facial recognition using OpenCV. *Journal of Mobile, Embedded and Distributed Systems*, *4*(1), 38-43.
  19. Boyko, N., Basystiuk, O., & Shakhovska, N. (2018, August). Performance evaluation and comparison of software for face recognition, based on dlib and opencv library. In *2018 IEEE Second International Conference on Data Stream Mining & Processing (DSMP)* (pp. 478-482). IEEE.
  20. Suwarno, S., & Kevin, K. (2020). Analysis of face recognition algorithm: Dlib and opencv. *Journal of Informatics and Telecommunication Engineering*, *4*(1), 173-184.
  21. Tuhin, A. I. (2023). *Hospital Management System*. Independent University, Bangladesh