

AI-DRIVEN EXPERT SYSTEM FOR DYNAMIC DISEASE PREDICTION USING FACIAL EXPRESSION, VOICE PATTERNS AND EMOTIONAL METRICS

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ABSTRACT

Technology incorporation into the medical field supports to maintain the patient data in digital form to provide productive healthcare services. It supports remotely by enabling humans to consult with healthcare experts without physical presence and non-utilization of facilities. This approach offers the convenient remote access by overcoming significant challenges in providing holistic care based on emotional well-being or mental state during remote interactions. Traditional systems fail to offer personalized expert recommendations tailored to the dynamic needs of the human relying instead on more generalized approaches. This proposed approach introduces an AI-powered healthcare system to overcome these limitations by integrating advanced machine learning techniques such as Temporal Convolutional Neural Networks (TCNN) for facial expression recognition to assess emotional states and Convolutional Neural Networks (CNN) for speech recognition to capture vocal patterns. Furthermore, Natural Language Processing (NLP) is employed to understand the semantic content of patient speech enabling a comprehensive analysis. A key feature of the system is the use of content-based filtering to recommend healthcare expert's best suited to the specific condition. The integration of secure video consultation services allows for real-time monitoring and assessment of the facial expressions and speech patterns during the consultation. The system also includes a feedback mechanism to continuously improve expert's recommendations and the performance of the model is enhanced during every prediction. By providing personalized recommendations and real-time emotional insights this AI-driven solution addresses the shortcomings of traditional support services. This system marks a significant step forward in medical field combining machine learning with human-centered care to deliver a better remote healthcare experience.

1. INTRODUCTION:

The Health Sector (HS_i) refers to the delivery of health care over the web using a range of telecommunications methods diverged in "i" number of perspective based on the performance metrics. The [1] (HS_i) technologies include live video conferencing, mobile health apps, electronic transmission, and remote patient monitoring. The (HS_i) is quickly expanding and has the potential to change the way millions of people receive health care by accessing in remote. The technologies, tools and services are quickly becoming a critical part that dominates the healthcare system. The (HS_i) uses the application of emerging technologies to

offer and facilitate health care with relevant demanding services such as health information's (X_n) and creates awareness on day to day practice. Although the terms (HSi) and telemedicine are sometimes interchanged and encompasses a broader range of digital healthcare activities with appropriate services. To comprehend the relationship between (HSi) and telemedicine it is necessary to define telemedicine. Telemedicine is the integrated application of technology and telecommunication networks to provide healthcare to demanding people who are geographically distant from the experts. For eg: A radiologist might analyze and interpret imaging results for a particular case in a distant county whose hospital currently lacks a radiologist. For a non-life-threatening health condition a physician may provide urgent care to the patient through video. Telemedicine are growing rapidly by the practice of medicine through the internet and electronic applications. The (HSi) activities and uses that go beyond remote clinical treatment include wearable devices that record and transmit vital signs, and provider-to-provider remote communication. With the advancement of the smartphones mHealth (mobile health), remote patient monitoring (RPM), video and audio technology, digital photography and forward technologies are all being encouraged to use for (HSi).

2. LITERATURE REVIEW:

In 2018, the management of patient information in healthcare sector has evolved significantly with the advancement of web-based systems, database servers and computer applications with productive features.[2] Later, several research studies highlights the inefficiencies in traditional healthcare maintenance system including extracting the hidden sensitive information, fragmenting the data, transferring the data results in security concerns that clearly states the limitation emerge in accessing the stored data when demand emerges by the experts. Most of the research on (HSi) in major operational locations like the University of Malaysia and University Kebangsaan Malaysia has identified challenges. The challenges are delayed appointment scheduling, difficulty in tracking medical observed records and inefficient communication between patients and medical experts. [3] The web-based integrated healthcare systems have been proposed as a solution to streamline the challenges by utilizing the computing strategies to produce dynamic effective solutions that supports remotely. The existing literature [4] suggests that such systems enable self-service functionalities allowing the user to schedule appointments, access their medical history and track the availability of the experts on demand virtually. This solution not only optimizes the administrative workflows but also reduces the processing times and enhances overall healthcare efficiency. Implementing a secure and user-friendly system can significantly benefit both medical expert and user. In 2021, the integration of Information Technology Infrastructure Library (ITIL) frameworks in healthcare applications has been widely studied to enhance service reliability and efficiency. Previous research highlights [5] the need for continuous, quality healthcare services, especially during crises like pandemics, where accessibility and system reliability are crucial. The implementation [6] of AI based dynamically disease prediction system that manages and monitor all the sub functionalities embedded in the designed applications that ensures seamless user / expert interactions and also minimizes service disruptions. The mobile applications particularly those developed using cross-platform frameworks like React Native have gained popularity due to their flexibility and cost-effectiveness. Most of the research studies also emphasize the importance of secure data storage with cloud-hosted databases like Mongo DB providing scalable solutions for managing sensitive medical information. The incorporation of Agile Methodology in healthcare IT projects became very popular due to its iterative nature allowing for rapid development and adaptability to user needs. Furthermore, adherence to IEEE standards for software testing enhances application reliability ensuring compliance with industry benchmarks for performance and security. In 2022, the development of web-based e-Health applications has significantly transformed healthcare by enabling experts to access sensitive records, tracking medication history and conduct online consultations. The research

highlights [7] that integrating artificial intelligence (AI) into these systems enhances disease detection and biological data analysis improving diagnostic accuracy and treatment planning. AI-driven healthcare platforms offer real-time monitoring of vital signs allowing medical professionals to make informed decisions quickly. Studies [8] suggest that online consultations when supplemented with real-time data visualization and historical medical records improve accessibility and efficiency in healthcare delivery. Additionally, software engineering practices play a crucial role in optimizing these platforms for reliability and security. The future trends indicate a growing reliance on online medical services particularly for managing contagious diseases and chronic conditions that require continuous monitoring reinforcing the importance of digital healthcare solutions.

In 2023, the integration of machine learning and digital platforms in healthcare has led to significant advancements in patient data management and service accessibility. Research highlights that vast amounts of hospital-generated data can enhance machine learning algorithms enabling automated solutions for treatment, diagnosis, and medication management. The Indian government's United Health Interface (UHI) initiative is a major step towards digital healthcare transformation aiming to consolidate various services such as health record storage, blood bank management, hospital information and medical insurance. Few research studies suggest that secure and interoperable health networks improve healthcare efficiency by ensuring seamless medical data sharing across different research institutions. Additionally, online expert appointment systems have been recognized for their convenience, cost-effectiveness and enhanced user management. [9] By integrating these technologies into a single web application healthcare accessibility and efficiency can be significantly enhanced by offering the user a seamless experience while supporting healthcare providers in delivering timely and informed medical decisions.

In 2024, the integration of artificial intelligence (AI) in healthcare has led to the development of medical Chatbot's which aim to improve user access to medical information and reduce healthcare costs. The research highlights that AI-powered Chatbot's serve as virtual assistants offering preliminary diagnoses based on symptom analysis and providing users with relevant health information. These Chatbot's improve healthcare accessibility by assisting individuals in identifying potential illnesses before consulting a doctor. The studies also emphasize that Chatbot's enhance user awareness and promote preventive care by offering tailored health recommendations. However, their effectiveness depends on their ability to accurately diagnose a wide range of diseases. Additionally, advancements in AI-driven healthcare systems include automated medicine dispensers that distribute medications based on digital prescriptions ensuring accurate and timely drug delivery. The integration of such systems streamlines healthcare services, minimizes human errors and enhances patient experience making AI-powered solutions a promising tool for modern healthcare management.

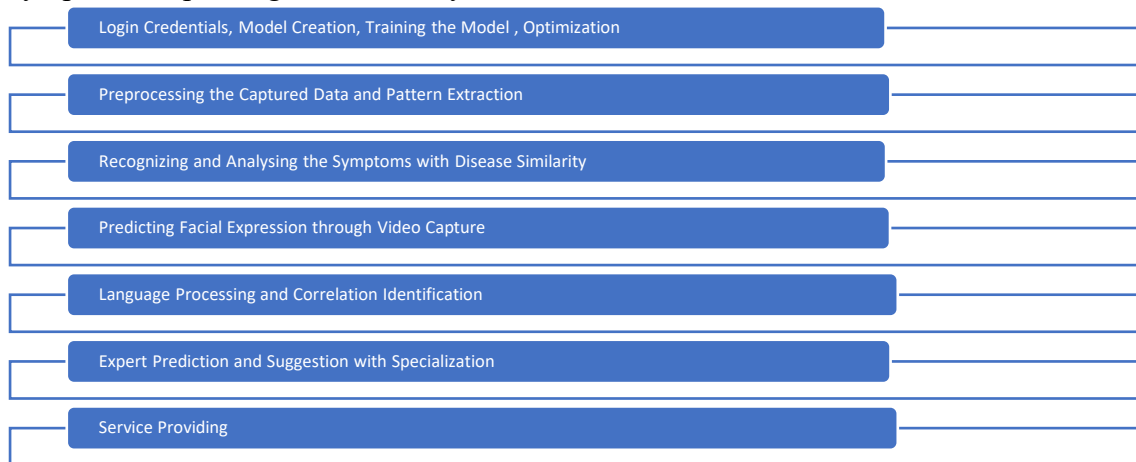
3. PROBLEM DEFINITION:

Access to timely and personalized medical consultations remains a critical challenge in modern healthcare. Patients frequently face difficulties in identifying the right healthcare professionals leading to delays in diagnosis and treatment. Traditional telemedicine platforms primarily rely on textual or video-based consultations, lacking advanced AI-driven capabilities such as Facial Expression Recognition (FER), Speech Recognition and Semantic Analysis. This absence of multi-modal analysis restricts a doctor's ability to assess a patient's psychological and emotional well-being potentially leading to misdiagnoses and suboptimal treatment. Additionally, the lack of an intelligent recommendation system results in inefficient patient-doctor matching as existing systems do not consider a patient's symptoms, emotional state and medical history comprehensively. This mismatch reduces treatment effectiveness, increases patient dissatisfaction and contributes to inefficiencies in healthcare service delivery.

Furthermore, the reliance on manual consultation scheduling and generalized recommendations further limits the accessibility and personalization of remote healthcare services. To overcome these challenges this research proposes an AI-powered Healthcare Consultant Web Application integrating Machine Learning, Natural Language Processing (NLP), Deep Learning and Computer Vision. This system enhances remote healthcare by providing real-time emotional and speech analysis, intelligent doctor recommendations and secure video consultations, ensuring a more accurate, efficient and personalized healthcare experience.

4. PROPOSED METHODOLOGY:

The proposed AI-driven dynamic disease prediction system utilizes facial expression and voice pattern to recommend suitable healthcare experts and facilitate video consultations. The system integrates machine learning algorithms and techniques to analyse patient emotions and symptoms improving the efficiency of virtual healthcare services.



The methodology consists of the in the proposed model are depicted in the Fig 1 with its key functional modules such as the central hub – AI Healthcare consultant app, that comprised into four major analytical parts that takes the responsibility in executing the video consultation with the core performance metrics such as facial expression, voice and expressing the emotions. The combined characteristics of all the user actions are collected, pre-processed, analysed and predicted the target expectation of the user. The widely used computing techniques are integrated into the functionality of the AI based system and implemented the online supportive system that also used the language processing feature also as a major functional components. The integration of the computing techniques hides the demerits associated with each strategies so the performance deviation is measured in terms of ignorance level, and ensured that will not affect the performance of the proposed system. The crucial attributes are well analysed and utilized in the level of higher standard.

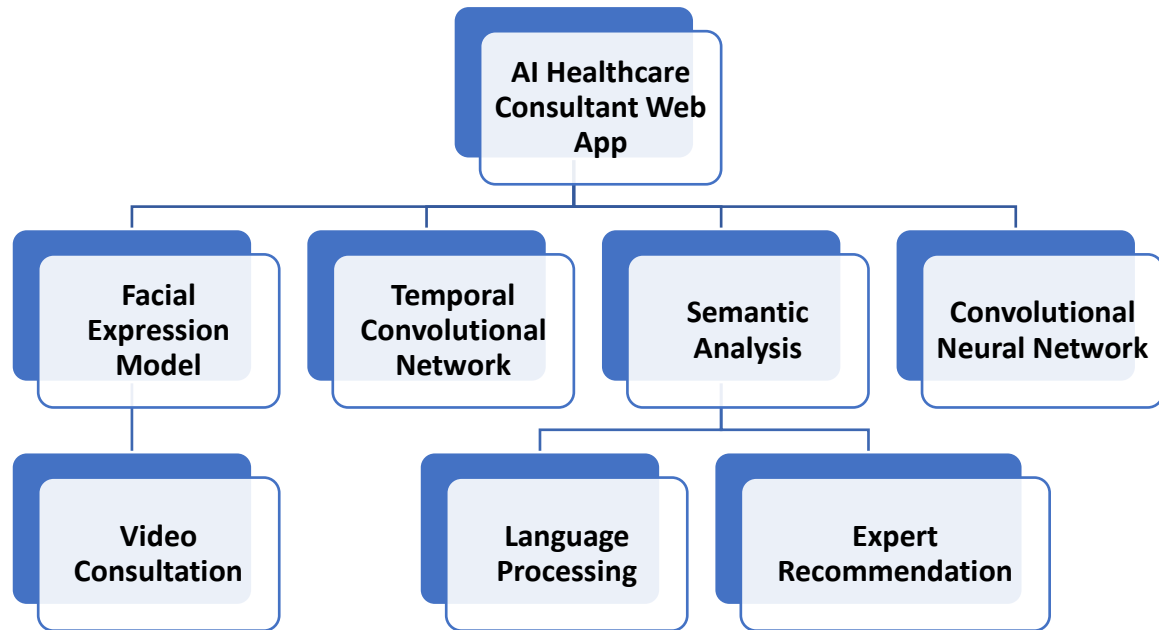


Fig: 1 Functional Modules

4.1 AI Healthcare Consultant Web App, this serves as the central hub for the integrated healthcare system providing a user-friendly interface that seamlessly integrates advanced technologies. This platform plays a pivotal role in enhancing patient care by consolidating various functionalities including facial expression analysis, speech recognition, and semantic understanding with appropriate recommendations. The design and development of an AI Healthcare Consultant Web App aim to revolutionize remote healthcare services by integrating advanced technologies. The **Dashboard** providing a secure login interface for the admin to access the system that allows experts to review and registrations. It also enables experts to train the Facial Emotion Recognition (FER) model to analyse patient emotional states that are needed to manage the overall user data including healthcare professionals and patients with permissions and roles.

4.2. Facial Expression Model: Build and Train- Import Dataset -In this module, datasets that include labeled facial expression are imported. The Pre-processing is an essential step in preparing the data for model training. After importing, the dataset is preprocessed by resizing the image to uniform dimension converting colored image to grayscale to reduce computational complexity, applying noise filters to remove unnecessary noise and binarizing image for easier analysis. Feature extraction is carried out using three layers i.e, Convolutional, Activation and Pooling layers to capture low-level features such as edges and textures. It adds non-linearity, enhancing the model’s ability to learn complex features and reduces spatial dimensions while preserving the most critical features. The extracted features are passed through a Fully Connected Layer for classification. This layer maps the extracted features to specific facial expression categories, allowing the model to predict emotions such as sadness, stress, discomfort, neutrality etc. Using ExpNet, facial image dataset is built and trained to detect emotions from facial expressions with high accuracy. It is specifically designed using the architecture of Convolutional Neural Network (CNN) to handle facial expression recognition tasks. The trained Facial Expression Recognition model is integrated into the AI Healthcare Consultant Web App. This allows for real-time facial expression analysis during patient consultations, ensuring seamless and efficient interaction for emotional assessment during video consultations.



Fig : 1 Facial Expression Recognition

Live video feeds from patients are captured through the web cameras. For facial expression recognition from the live feed, an algorithm, Temporal Convolutional Neural Networks (TCNN) are utilized. TCNN captures temporal dependencies in facial movement ensuring that emotions are accurately classified over time. This enables a more dynamic and comprehensive understanding of emotional states during video consultations.

➤ **Temporal Convolutional Network (TCNN) Module:**

It applies 1D Convolutional Layers across the time dimension to learn temporal patterns. It uses dilated convolutions to capture long-range dependencies in facial expressions. Incorporation of residual connections to avoid vanishing gradient problems. It applies Global Average Pooling (GAP) to reduce feature dimensionality. Uses fully connected layers to classify emotions and Softmax activation function for multi-class classification. **Speech Recognition** - Spoken language from patients are captured during video consultations. The system processes the spoken input to understand the patient's voice for further analysis and communication. In this step, noise from the audio input is removed using Wavelet Filters to enhance the clarity of the speech. This ensures that the spoken words are accurately captured and processed for analysis. The speech is normalized for better learning. Features are extracted from the pre-processed speech signals using Mel Frequency Cepstral Coefficients (MFCC). MFCC captures vocal tone variations, which are crucial for emotion detection in speech and also captures other essential features of the spoken language enabling better recognition and understanding of the patient's speech. Fourier Transform (FT) converts each frame into frequency domain. Convolutional Neural Networks (CNN) are used to recognize the extracted speech features. CNN processes the audio data to identify and categorize the spoken language which is crucial for semantic understanding.

Convolutional Neural Network Module: It Accepts MFCC spectrograms of shape (Height × Width × Channels). Extract spatial features from MFCC representations. It uses ReLU activation for non-linearity. Apply Max Pooling (2×2) to downsample the feature maps. Normalize feature maps to improve convergence. Apply Dropout (0.3–0.5) to prevent overfitting. Flatten convolutional features and pass through dense layers. Use Softmax activation to classify speech into emotion categories. Loss Function: Use Categorical Cross-Entropy for multi-class classification. Optimizer: Implement Adam optimizer (learning rate = 0.001) for adaptive learning. Batch Size & Epochs: Train with a batch size of 32 for 50–100 epochs. Monitor validation loss and stop training if overfitting is detected. Finally, the recognized speech is converted into text. This enables the system to analyse and interpret the patient's spoken language in a meaningful way for further processing.

Semantic Insights

The Semantic Insights module leverages Natural Language Processing (NLP) techniques to understand and analyze patient symptoms and communication. It processes textual data obtained from speech-to-text conversion, patient queries or symptom descriptions to extract meaningful insights related to emotional states, medical conditions or concerns. **Natural Language Processing Module:** Take speech transcriptions generated from the CNN-based speech recognition model. Preprocess the transcriptions by:

- Removing filler words ("um", "uh", "like")

- Normalizing punctuation and casing
- Expanding contractions (e.g., "I'm" → "I am")

Tokenization and Vectorization -The text data is tokenized and converted into numerical vectors for machine learning models to process. Entity Recognition- Named Entity Recognition (NER) identifies and categorizes key entities like symptoms, diseases and medications. Sentiment analysis is performed to understand the emotional tone of the patient's speech or text. Semantic Relationship Extraction: Relationships between symptoms, diseases and treatments are extracted to provide a deeper understanding of patient needs.

Expert Recommendation – This module is designed to provide personalized and efficient healthcare by recommending the most suitable healthcare professionals for patients based on their specific needs. This module integrates multiple sources of patient data including facial expressions, speech and semantic insights to create a comprehensive understanding of the patient's condition. Patient data from various sources such as facial expressions, speech recordings and NLP-based semantic analysis are collected and processed to create a detailed profile of the patient's emotional and medical state. These features provide a rich, multidimensional representation of the patient's condition. Extract patient details from speech and facial expression analysis. Use NLP-based Named Entity Recognition (NER) to extract symptoms, medical conditions, emotion and sentiment scores. Convert doctor profiles into text feature representations using TF-IDF and Bag of Words. Represent patient symptoms and extracted concerns as a vectorized text document. Compute cosine similarity between the patient symptom vector and doctor profile vectors. Rank doctors based on highest similarity scores. Use Facial Expression Recognition (CNN-based TCNN model) and Speech Sentiment Analysis to determine patient emotional state. Assign urgency scores based on emotions for high priority for distress signals. Lower priority for neutral or non-critical symptoms. Adjust doctor ranking based on emotional severity. Select Top-N most relevant expert based on:

- Cosine similarity score (symptom-doctor match)
- Urgency score (emotion-based priority)

Video Consultation Services

The Video Consultation Services module provides a secure and efficient platform for patients to engage in virtual consultations with healthcare professionals. This service allows patients to interact with doctors in real-time through video enabling a comprehensive assessment of their health concerns while maintaining privacy and confidentiality. During the consultation patients can describe symptoms, ask questions and receive expert advice while healthcare professionals can observe facial expressions and gestures to gain insights into the patient's emotional and physical well-being. This dynamic interaction facilitates a deeper understanding of the patient's condition and enhances the overall diagnostic process. The integration of AI-driven tools such as facial expression analysis and speech recognition further improves the accuracy of consultations by analyzing non-verbal cues and spoken language. These insights contribute to a more holistic approach to patient care.

RESULT AND DISCUSSION:

The system was deployed as a web-based application enabling users to interact with experts remotely. The system was evaluated on a dataset containing facial images, speech recordings and patient symptom data. Several key performance factors were observed Facial Expression Analysis with the CNN model accurately detected expressions such as sadness, stress and discomfort which were mapped to emotional states influencing doctor recommendations. Speech-Based Sentiment Analysis: The TCNN and NLP models effectively identified positive, neutral and negative sentiments, aiding in the prioritization of consultations for critical cases. The Content-based filtering successfully matched patients with appropriate experts.

CONCLUSION:

In conclusion, the integrated healthcare system harnesses the power of facial expression analysis, speech recognition and Natural Language Processing (NLP) within a content-based filtering framework to revolutionize patient care. By incorporating advanced AI algorithms, the system offers a personalized patient-centric approach, ensuring that recommendations for healthcare professionals are both accurate and tailored to individual needs. The dynamic nature of the Content-Based Filtering for expert Recommendation allows for continuous refinement of suggestions based on evolving patient feedback ensuring ongoing relevance and effectiveness. Overall, this system represents a significant step toward transforming the future of healthcare offering a technology-driven, patient-centered approach that addresses both physical and emotional aspects of care.

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