

MENTAL HEALTH DETECTION USING LOGISTIC REGRESSION

D.Aparna¹ Ch.Vinaykumar², G.Srividhya³, P.KranthiKumar⁴, Ch.Prashanthika⁵, Ramdas Vankdothu⁶, Suman D⁷

^{2,3,4,5}B Tech Student, Department of CSE, Balaji Institute of Technology and Science, Laknepally, Warangal, India.

^{1,6,7} Assistant Professor, Department of CSE, Balaji Institute of Technology & Science, Laknepally, Warangal, India.

ABSTRACT

Machine learning is transforming early mental health diagnosis by analyzing behavioral data, psychological assessments, and physiological signals. This study applies NLP for social media analysis, wearable sensor data interpretation, and EHR mining to detect conditions like depression, anxiety, and bipolar disorder. AI models enhance diagnostic accuracy, supporting mental health professionals with timely insights. Ethical concerns, implementation challenges, and future AI advancements in mental healthcare are also discussed. The integration of AI-driven techniques holds the potential to personalize mental health treatments. Continuous improvements in algorithms can further refine predictive capabilities, making interventions more effective. In our project, the model performed with an accuracy of around 90%, reflecting its effectiveness in making correct predictions.

Logistic regression: A statistical method for binary classification that models the probability of an outcome using a logistic function.

Steps of the Logistic Regression Algorithm

1. Collect the Data

Start by gathering the dataset that contains both input features (independent variables) and the output labels (dependent variable — binary like 0 or 1).

2. Preprocess the Data

- Clean the dataset by handling missing values or duplicates.
- Normalize or scale the data if needed.
- Split the dataset into training and testing sets.

3. Initialize the Parameters

- Assign initial values (often zero or small random numbers) to the model's weights and bias.

4. Compute the Weighted Sum (Linear Equation)

For each data point, compute the linear combination of the features and weights:

$$Z = b_0 + b_1 * x_1 + b_2 * x_2 + \dots + b_n * x_n$$

5. Apply the Sigmoid (Logistic) Function

Convert the linear output z into a probability value using the sigmoid function:

$$P = 1 / (1 + e^{(-Z)})$$

This squashes the value between 0 and 1.

6. Define the Loss Function

Use Binary Cross-Entropy (Log Loss) to measure how far the model's predictions are from the actual values:

$$\text{Loss} = - [y * \log(P) + (1 - y) * \log(1 - P)]$$

7. Optimize the Parameters (Gradient Descent)

- Calculate the gradients of the loss function concerning weights and bias.
- Update the weights and bias to minimize the loss:

$$\text{weight} = \text{weight} - \text{learning_rate} * \text{gradient}$$

Repeat this step for multiple iterations (epochs) until the model learns well.

8. Make Predictions

After training, compute the probability for new input data using the learned weights and bias. If the probability is above 0.5, classify it as 1 (positive class), else 0 (negative class).

9. Evaluate the Model

Use metrics like:

- Accuracy
- Precision
- Recall
- Confusion Matrix

To check how well the model is performing on unseen test data.

10. Deploy the Model

Once satisfied with the model's performance, deploy it in a real-world application for making predictions.

Decision tree: A tree-based model that splits data into branches based on feature conditions to make predictions.

Simple Steps to Understand How a Decision Tree Works

1. Start with the Whole Dataset

Look at all the data you have and decide which feature (or question) will best divide it into meaningful groups.

2. Pick the Best Question to Split

Find the feature that separates the data most clearly. This could be something like "Is age greater than 30?"

3. Split the Data into Two or More Groups

Based on the answer (yes or no), break the dataset into smaller parts.

4. Repeat the Process for Each Group

Keep asking new questions for each group created. The goal is to get groups that are as pure as possible — meaning, mostly belonging to one category.

5. Stop When You Meet a Condition

The splitting stops when:

- All the data in a group belongs to the same class
- You reach the maximum depth
- There's no improvement in splitting

6. Make the Final Decision

At the end of the branches (called leaf nodes), you get your result — like "Yes, it's a positive case" or "No, it's negative".

Random forest: An ensemble learning method that combines multiple decision trees to improve accuracy and reduce overfitting.

How Does It Actually Work? (Step-by-Step)

1. Create Multiple Random Samples

The algorithm randomly picks different portions of the original dataset — sometimes with repeated values — creating several small datasets called "bootstrapped samples."

2. Build a Decision Tree for Each Sample

For every random sample, a decision tree is created. But here's the twist — at each split, the tree randomly selects a few features instead of considering all of them. This keeps the trees different from each other.

3. Grow Many Trees

This process repeats until a forest — made of hundreds or even thousands of trees — is built. Each tree grows fully without pruning.

4. Make Predictions with Voting

Once the forest is ready, it's time to predict:

- If it's a classification problem, every tree gives its vote (like *Yes* or *No*), and the majority wins.
- For regression problems, the average of all tree predictions is taken.

5. Final Decision is More Accurate

Since the final prediction is based on multiple trees, it reduces errors and avoids being tricked by random noise in the data.

SVM(support vector machine) :A machine learning algorithm that finds the optimal boundary to separate different classes in high-dimensional space.

How Does SVM Actually Work?

1. Imagine a Line or a Boundary

Think of two groups of points drawn on paper. Now, SVM tries to draw a straight line (or a plane if the data has more than two features) that separates these two groups with the maximum possible distance between them.

2. Focus on the Hardest Points (Support Vectors)

Interestingly, SVM doesn't care about all the points — it only focuses on the data points closest to the separating line. These points are called support vectors because they "support" the position of the line. If you remove other points, the line stays the same, but if you remove a support vector, the line changes.

3. Create a Safety Margin

SVM makes sure there's a safe gap, known as the margin, between the two groups. The wider this margin, the better the model is expected to perform when it sees new data.

4. Handles Complex Data with Kernel Trick

Not all data can be separated with a straight line. So, SVM has a smart trick called the kernel

function that bends the space and finds a way to separate the groups, even if the data is tangled. Think of it as drawing a curve instead of a straight line if that helps.

1. INTRODUCTION

This project focuses on developing an AI-powered system for detecting mental health conditions like depression, anxiety, and stress through natural language processing (NLP). By analyzing textual data from social media, clinical records, and standardized questionnaires, the system extracts linguistic and behavioral features to identify psychological distress. Machine learning models, including SVMs, Random Forest, LSTMs, and transformer-based architectures like BERT, are employed to enhance predictive accuracy. Ethical considerations such as bias mitigation, data privacy, and transparency are prioritized to ensure responsible AI deployment. Future enhancements aim to expand detection to disorders like PTSD and integrate multi-modal AI for improved assessment. Through interdisciplinary collaboration, this initiative seeks to bridge the gap between AI and mental healthcare, promoting early intervention and personalized treatment strategies [1-17].

2. LITERATURE SURVEY

1. Artificial Intelligence in Mental Health Care: A Systematic Review of Diagnosis, Monitoring, and Intervention Applications(2021)

Authors: Graham S, Depp C, Lee EE, et al.

Objective: To systematically evaluate how AI can transform mental health care, potentially leading to more accurate diagnoses, personalized treatment plans, and efficient resource allocation.

Algorithms Used:

Natural Language Processing (NLP): For analyzing textual data from clinical notes and patient interviews.

Machine Learning Classifiers: Such as Support Vector Machines (SVM) and Random Forests for predictive modeling.

Strength: Comprehensive evaluation of AI applications in various aspects of mental health care.

Weakness: Limited by the quality and heterogeneity of included studies.

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3. Artificial Intelligence in Positive Mental Health: A Narrative Review(2023)

Authors: Thakkar A, Gupta A, De Sousa A.

Objective: To review the spectrum of AI applications in mental health and its positive role.

Algorithms Used:

Natural Language Processing (NLP): For sentiment analysis and mood detection.

Machine Learning Models: Including Decision Trees and Neural Networks for predictive analytics.

Strength: Highlights the potential of AI in enhancing mental well-being and early detection of mental health issues.

Weakness: Emphasizes the need for ethical considerations and addresses challenges in data privacy.

4. Use of Generative Artificial Intelligence in Psychiatry and Mental Health Care: A Systematic Review(2024)

Authors: Not specified.

Objective: To review the applications of generative AI in psychiatry and mental health care.

Algorithms Used:

Generative AI Models: Such as GPT-3 and GPT-4 for generating human-like text in therapeutic settings.

Strength: Demonstrates the potential of generative AI in providing support and information to patients.

Weakness: Highlights significant safety and ethical concerns, including the accuracy of generated information and potential misuse.

3. EXISTING SYSTEM

AI in Mental Health Detection

Current artificial intelligence (AI)-driven systems for mental health assessment have transformed the way psychological conditions are detected and managed. These advanced solutions offer several benefits that enhance diagnostic precision, accessibility, and early intervention capabilities. Below are some of the key advantages:

1. Early Detection and Preventive Care

Predictive Modelling: AI-powered systems process extensive datasets to detect subtle indicators of mental distress, allowing for timely intervention before conditions escalate.

Proactive Monitoring: These technologies can continuously assess behavioral patterns, alerting individuals and healthcare providers to potential mental health concerns.

2. Enhanced Diagnostic Accuracy

Data-Driven Assessments: AI utilizes deep learning and statistical models to reduce human error and increase diagnostic consistency.

Pattern Recognition: Advanced algorithms analyse linguistic, behavioral, and physiological signals, identifying risk factors that traditional assessments might overlook.

3. Personalized Mental Health Support

Customized Treatment Plans: AI can tailor interventions based on individual psychological profiles, ensuring more effective mental health support.

Dynamic Learning: These systems adapt over time, refining recommendations as they gather more data from users.

4. Expanding Access to Mental Health Care

Remote Evaluation: AI tools enable mental health assessments to be conducted virtually, making psychological support accessible to remote and underserved populations.

On-Demand Assistance: Chatbots and AI-driven mental health platforms provide instant support, helping individuals manage emotional distress without needing immediate human intervention.

4. PROBLEM STATEMENT

The increasing prevalence of mental health disorders such as depression and anxiety has become a significant global concern. However, traditional methods of diagnosis often face challenges such as delays, subjectivity, and lack of accessibility, making early detection difficult. This project proposes the development of an AI-driven mental health assessment system that utilizes machine learning algorithms to analyze textual content, behavioral patterns, and physiological indicators for early identification of mental health conditions.

By incorporating Natural Language Processing (NLP), sentiment analysis, and predictive analytics, the system will generate real-time and highly accurate assessments of an individual's mental health. The primary aim is to facilitate timely interventions while ensuring data security, unbiased predictions, and scalable implementation, thereby improving accessibility to mental health support systems.

5. PROPOSED SYSTEM

AI-Driven Mental Health Detection

The proposed system integrates artificial intelligence (AI) and data analytics to detect early signs of mental health conditions. By leveraging behavioral data, speech analysis, and predictive modelling, this system aims to provide timely insights and personalized recommendations for individuals at risk.

1. Data Acquisition

Self-Reported Assessments

Utilizing validated psychological screening tools, such as PHQ-9 (depression assessment) and GAD-7 (anxiety measurement), to gather insights directly from users.

Conducting surveys to capture subjective emotional states and cognitive well-being over time.

Behavioral Data Monitoring

Tracking sleep cycles, activity levels, and social engagement through wearable devices, smartphone applications, and sensor-based technology.

Identifying variations in routine behaviours that may signal emotional distress.

Textual and Vocal Analysis

Extracting linguistic patterns from social media content, email exchanges, and digital conversations to detect psychological shifts.

Analyzing speech tone, pitch, and fluency in recorded voice samples to identify subtle indicators of stress, anxiety, or depression.

2. Data Preprocessing & Feature Engineering

Data Refinement

Eliminating irrelevant noise, duplicate entries, and inconsistencies to ensure high-quality input.

Standardizing text inputs through tokenization, stemming, and sentiment normalization.

Feature Identification.

Extracting meaningful indicators such as word frequency, tone variations, emotional sentiment, and physiological markers from collected data.

Utilizing natural language processing (NLP) techniques to recognize negative thought patterns and distress signals.

3. Model Development & Training

Algorithm Selection

Implementing machine learning classifiers such as Support Vector Machines (SVM), Decision Trees, and Random Forests for structured analysis.

Exploring deep learning architectures like LSTMs, CNNs, and Transformer-based models (e.g., BERT, RoBERTa) for enhanced accuracy in complex text and speech interpretation.

Training & Validation Approach

Splitting datasets into training, validation, and test subsets to optimize model performance.

Employing cross-validation techniques to ensure robustness and minimize bias.

4. Detection & Risk Prediction

Real-Time Analysis

Implementing live monitoring systems that assess incoming data and provide instant feedback on potential risks.

Using dynamic risk profiling to assign severity scores based on observed behavioral deviations.

Predictive Insights

Generating personalized risk assessments to help users and healthcare professionals understand mental health trends.

Providing early warnings and alerts for individuals exhibiting symptoms of psychological distress.

5. User Interface & Interaction

Personalized Dashboard

Designing an interactive user interface that visually represents mental health trends, emotional states, and risk factors.

Offering personalized reports based on analyzed data and AI-driven insights.

Support & Intervention Tools

Recommending self-help programs, mindfulness exercises, and coping strategies based on detected emotional patterns.

Integrating mental health support services, including direct access to therapists, crisis hotlines, and emergency intervention teams.

6. Privacy, Security & Ethical Compliance

Data Protection & Anonymization

Applying encryption techniques and anonymization protocols to prevent the misuse of personal information.

Ensuring compliance with global data protection standards, including GDPR (General Data Protection Regulation) and HIPAA (Health Insurance Portability and Accountability Act).

Bias Mitigation & Fairness

Conducting regular bias audits to ensure that AI predictions are fair, unbiased, and applicable across diverse demographics.

Implementing transparent AI decision-making to enhance user trust and reliability.

7. Continuous Improvement & Model Refinement

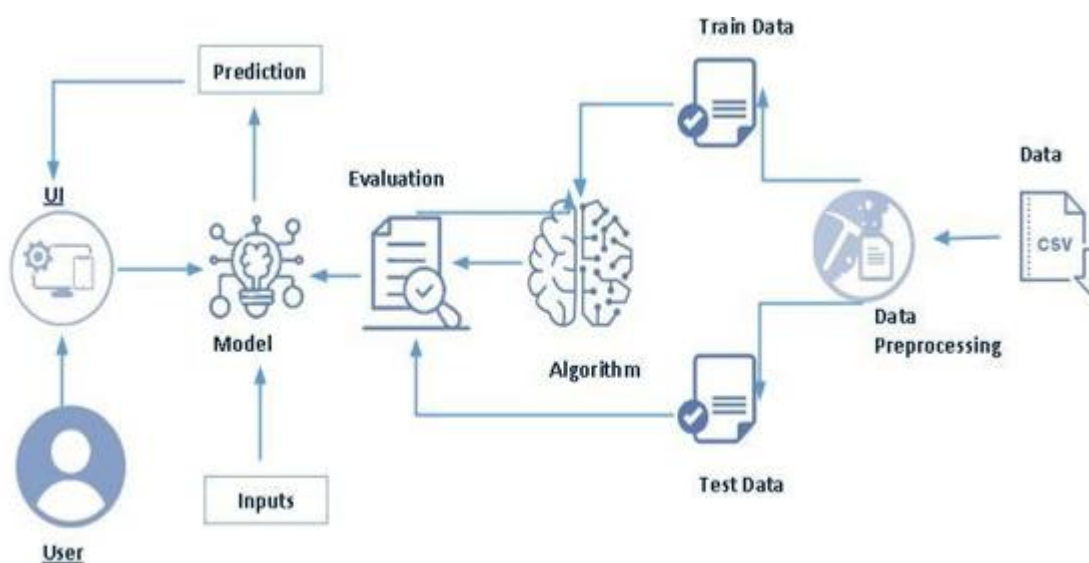
Feedback-Driven Learning

Incorporating user feedback and clinical validation to refine model predictions and enhance accuracy.

Updating AI models periodically to integrate new behavioral patterns, emerging mental health trends, and clinical research advancements.

Adaptive Model Evolution

Enabling the system to self-improve over time by retraining on new datasets and real-world interactions.



6. METHODOLOGY

1. Data Acquisition & Processing

The system gathers data from multiple sources, ensuring a diverse and accurate dataset:

- **User Self-Assessments:** Structured psychological questionnaires (e.g., PHQ-9, GAD-7) to measure mental states.
- **Behavioural Indicators:** Sleep cycles, social interaction frequency, and daily activity patterns monitored via wearable devices and applications.
- **Text & Speech Analysis:** Social media posts, emails, and recorded conversations are examined for linguistic and vocal patterns indicative of mental distress.

Collected data undergoes preprocessing, including text normalization, removal of redundant information, and privacy-focused anonymization to safeguard user confidentiality.

2. Feature Engineering & Selection

To extract meaningful insights, relevant features are identified:

- **Linguistic Markers:** Word usage patterns, sentiment fluctuations, and grammatical structures.
- **Behavioral Signals:** Deviations from normal activity levels, irregular sleep, and communication shifts.
- **Speech Characteristics:** Tone, pitch variation, and speech fluency as potential indicators of psychological distress.

Advanced dimensionality reduction techniques are applied to refine data, ensuring optimal model efficiency and accuracy.

3. Machine Learning Model Development

A combination of traditional and deep learning algorithms is employed:

- **Classical Models:** Decision Trees, Random Forest, and Support Vector Machines (SVM) for structured analysis.
- **Deep Learning Approaches:**
 - LSTMs for sequential text and voice pattern recognition.
 - Transformer models (BERT, RoBERTa) for contextual understanding of textual data.

Training is conducted using partitioned datasets (training, validation, and testing), ensuring model robustness through cross-validation techniques. Performance metrics, including accuracy, precision, recall, and F1-score, are used to fine-tune model predictions.

4. Risk Prediction & Real-Time Monitoring

The AI system continuously evaluates user input to assess mental health risks:

- **Dynamic Risk Scoring:** Each input is assigned a severity score based on behavioral deviations and detected linguistic markers.

- **Personalized Insights:** Users receive mental health trend analyses and alerts when distress signals are identified.

This approach enables timely interventions, supporting both individuals and healthcare professionals with actionable insights.

5. User Experience & System Deployment

To facilitate real-world use, the system integrates with accessible platforms:

- **Interactive Dashboard:** A user-friendly interface displaying emotional trends and risk assessments.
- **API Integration:** AI models are deployed via RESTful APIs for seamless incorporation into healthcare and mental wellness applications.

6. Privacy, Security & Ethical Considerations

- **Data Protection:** Secure encryption methods are applied to anonymize user data, ensuring compliance with global privacy regulations.
- **Bias Reduction:** AI fairness audits are performed to prevent demographic-based biases, ensuring equal effectiveness across different user groups.

7. Continuous Learning & System Improvement

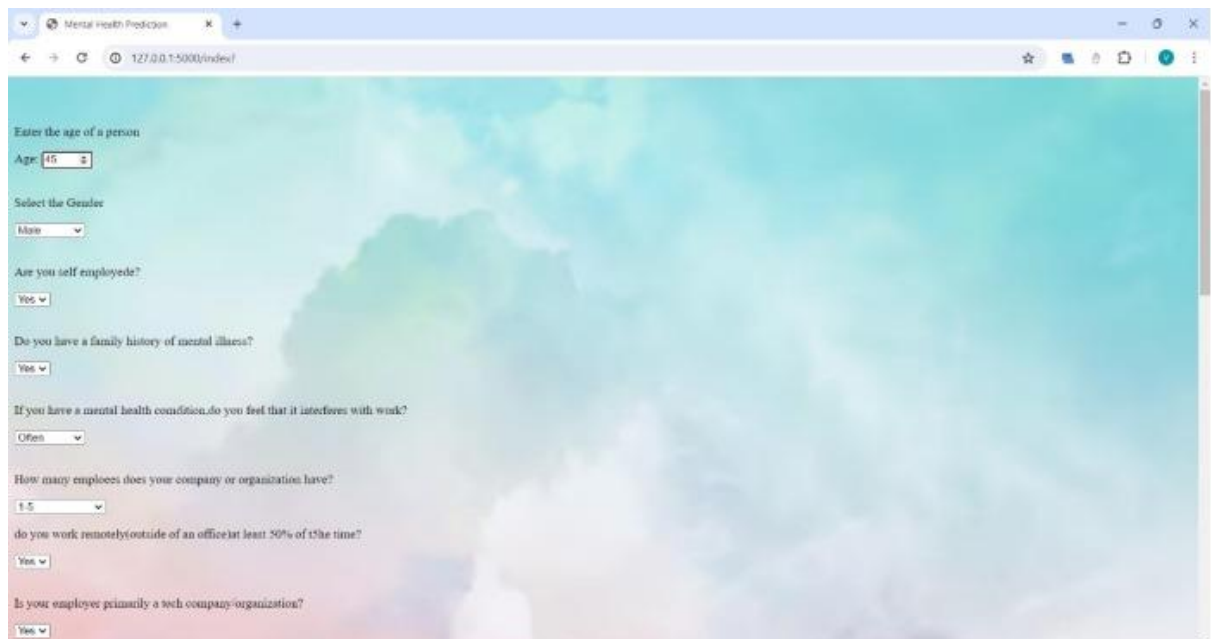
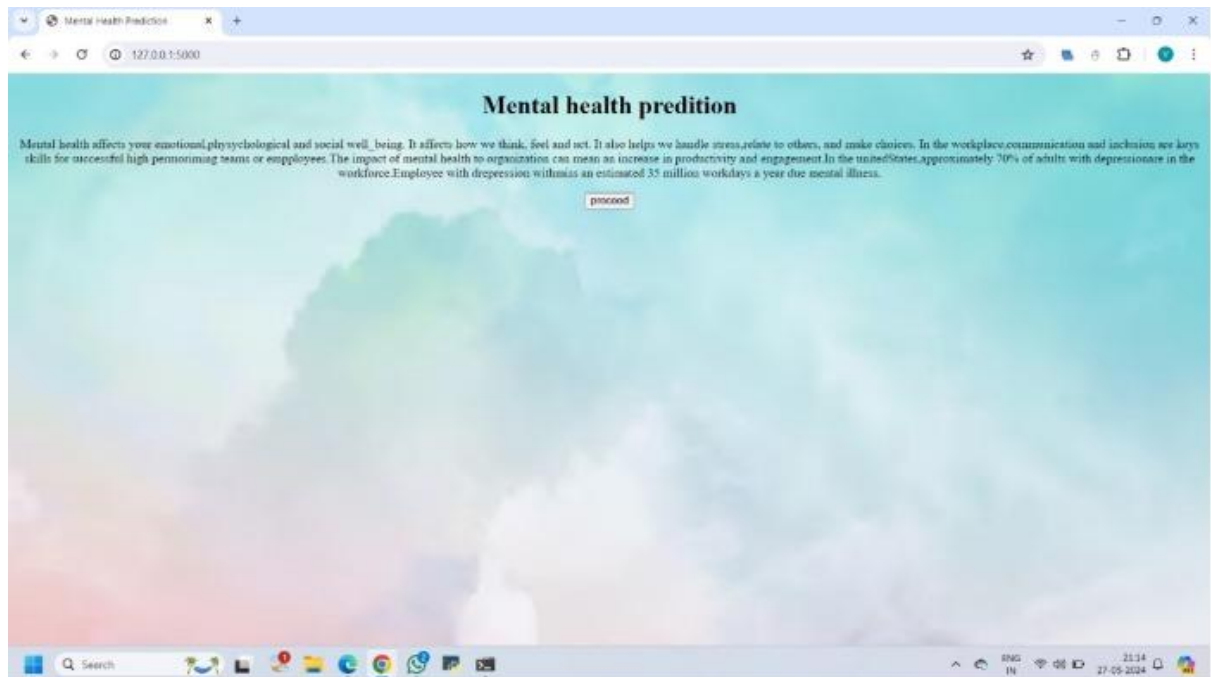
- **Feedback Mechanism:** Real-world user feedback is incorporated to enhance prediction reliability.
- **Adaptive Learning:** The model evolves over time by integrating new data and adapting to emerging mental health trends.

Logistic regression: A statistical method for binary classification that models the probability of an outcome using a logistic function.

Decision tree: A tree-based model that splits data into branches based on feature conditions to make predictions.

Random forest: An ensemble learning method that combines multiple decision trees to improve accuracy and reduce overfitting.

SVM(support vector machine) : A machine learning algorithm that finds the optimal boundary to separate different classes in high-dimensional space.



Mental Health Prediction

127.0.0.1:5000/index/

Is your employer primarily a tech company/organization?
Yes

Does your employer provide mental health benefits?
Yes

Does your employer provide options for mental health care your employer provides?
Yes

Has your employer ever discussed mental health as a part of an employee wellness program?
yes

Does your employer provide resources to learn more about mental health issues and how to seek help?
Yes

Is your anonymity if you choose to take advantage of mental health or substance abuse treatment resources?
Yes

How easy is it for you to take medical leave for a mental health condition?
Somewhat easy

Do you think that discussing a mental health issue with your employer would have negative consequences?
yes

Do you think that discussing a physical health issue with your employer would have negative consequences?
Yes

Mental Health Prediction

127.0.0.1:5000/index/

Do you think that discussing a mental health issue with your employer would have negative consequences?
yes

Do you think that discussing a physical health issue with your employer would have negative consequences?
Yes

would you be willing to discuss a mental health issue with your coworkers?
Yes

would you be willing to discuss a mental health issue with your direct supervisor(s)?
yes

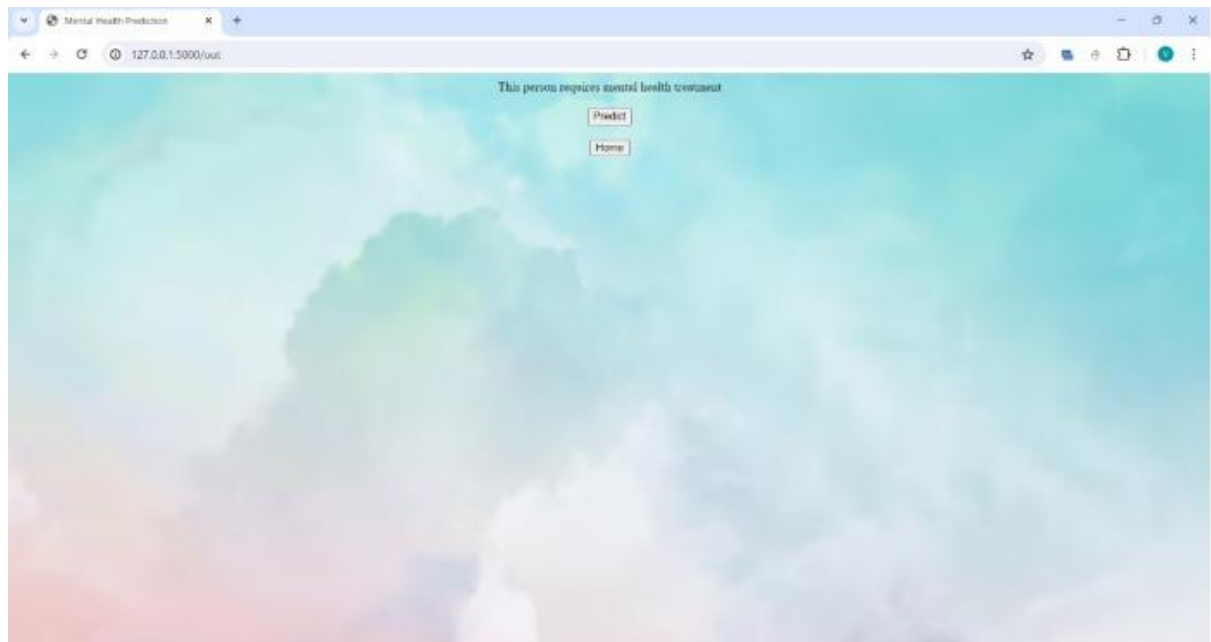
would you bring up a mental health issue with a potential employer in an interview
Yes

would you bring up a physical health issue with a potential employer in an interview
Yes

Do you feel that your employer takes mental health as seriously as physical health?
Yes

Have you heard of or observed negative consequences for coworkers with mental health condition in your workplace?
Yes

predict



7. FUTURE SCOPE:

1. Integration of Diverse Data Sources

To create a holistic assessment of mental health, future systems should integrate data from multiple sources, such as:

Text, Audio, and Video Analysis: Advanced AI models can analyse written content (e.g., social media posts), speech tone, and facial expressions to detect emotional states.

Wearable and IoT Data: Devices monitoring heart rate, sleep patterns, and physical activity can provide real-time physiological insights, improving mental health predictions.

2. Advanced Machine Learning Algorithms

Deep Learning Innovations: Next-generation neural networks, including transformers, graph neural networks, and CNNs, can refine the detection of subtle mental health markers.

Personalized AI Models: Future AI solutions should tailor predictions based on individual behavioural patterns, genetic factors, and environmental influences to offer more precise mental health recommendations.

3. Ethical Considerations and Bias Reduction

Ensuring fairness in AI-driven mental health assessments is crucial. Future developments should prioritize:

Bias Mitigation: AI models should undergo rigorous testing to detect and remove biases related to gender, race, or socio-economic factors.

Interpretable AI: Developing transparent algorithms that provide clear, explainable insights into how decisions are made can help build trust among users and healthcare professionals.

4. Predictive Analytics & Real-Time Monitoring

Continuous Tracking: Smartphones and IoT-based monitoring systems can help identify sudden behavioural shifts, allowing for timely mental health interventions.

Early Risk Prediction: AI-driven analytics can forecast potential mental health conditions before symptoms worsen, enabling proactive intervention strategies.

5. Strengthening Data Privacy & Security

With increasing concerns over data confidentiality, future advancements should emphasize:

End-to-End Encryption: Advanced cryptographic methods should protect data during both storage and transmission.

Federated Learning: By training AI models across decentralized data sources without sharing raw data, user privacy can be preserved while still improving model accuracy.

6. AI-Powered Support for Healthcare Professionals

Clinical Decision Support: AI-integrated mental health models can enhance Electronic Health Records (EHRs) by offering real-time recommendations to clinicians.

Telehealth Integration: AI-powered chatbots and virtual assistants can provide instant psychological support, particularly in remote or underserved areas.

7. Behavioural and Social Media Analysis

AI can examine patterns in social interactions, online behaviour, and communication styles to identify early signs of mental health conditions.

By analysing social media activity, AI can detect mood variations and predict emotional distress before it escalates.

8. Scalability and Global Accessibility

Expanding AI Solutions: Future developments should aim to scale mental health models to handle massive datasets and be adaptable across different regions and languages.

8. CONCLUSION:

The integration of artificial intelligence (AI) and machine learning (ML) in mental health detection is reshaping how mental health conditions are identified and managed. These technologies offer enhanced accuracy, efficiency, and personalization, enabling early diagnosis and timely intervention, which are crucial for improving patient well-being. By analyzing large datasets and identifying intricate behavioral patterns, AI-driven systems provide objective and data-driven insights, reducing the subjectivity often associated with traditional diagnosis methods. Moreover, customized treatment recommendations based on an individual's unique mental health profile ensure that interventions are more effective and tailored to specific needs. Another key advantage is the increased accessibility of mental health support, particularly for individuals in remote or underserved regions, where access to professional care may be limited. AI-based solutions, including real-time monitoring and digital therapy platforms, enable continuous mental health assessment, making support more readily available and scalable. As technology continues to advance, the role of AI in mental health care is set to expand further, driving proactive, precise, and inclusive mental health management. By combining scientific innovation with ethical considerations, future developments will ensure that AI-driven mental health solutions are trustworthy, equitable, and beneficial to all.

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I am Cheera Vinaykumar from the Department of Computer Science and Engineering. Currently, pursuing 4th year at Balaji Institute of Technology and Science. My research is done based on “Mental Health Detection Using Logistic Regression”.



I am Gurrām Srividhya from the Department of Computer Science and Engineering. Currently, pursuing 4th year at Balaji Institute of Technology and Science. My research is done based on “Mental Health Detection Using Logistic Regression”.



I am Potharaju Kranthikumar from the Department of Computer Science and Engineering. Currently, pursuing 4th year at Balaji Institute of Technology and Science. My research is done based on “Mental Health Detection Using Logistic Regression”.



I am Challa Prashanthika from the Department of Computer Science and Engineering. Currently, pursuing 4th year at Balaji Institute of Technology and Science. My research is done based on “Mental Health Detection Using Logistic Regression”.