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Behavioural Digital Twin for Predictive Personal Decision Making

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***Abstract*—The Behavioural Digital Twin is an intelligent system designed to create a virtual representation of an individual's decision-making behaviour. The objective of this project is to develop a predictive system that analyses user interactions, preferences, and behavioural patterns to anticipate future decisions. By leveraging Artificial Intelligence, Machine Learning, and behavioural analytics, the system learns from historical user data such as choices, activities, and contextual factors to construct a personalized digital twin.**

The proposed system collects behavioural data through user inputs and application interactions, processes the data using machine learning algorithms, and builds a behavioural profile for each user. This profile is used to predict potential future decisions, provide personalized recommendations, and simulate alternative decision outcomes.

The system utilizes classification and pattern recognition models to analyse behavioural trends and generate predictions. Visualization dashboards provide insights into behavioural tendencies and prediction results. This project demonstrates how digital twin technology can be applied beyond industrial systems to human behavioural modelling, enabling applications in personalized assistance, decision support systems, and intelligent recommendation platforms.

I. INTRODUCTION

Human decision-making is influenced by multiple factors including preferences, habits, environment, emotional states, and past experiences. With the rapid advancement of Artificial Intelligence and data analytics, it is now possible to analyse these behavioural patterns and predict future actions.

A Digital Twin is a virtual model that replicates the behaviour and characteristics of a real-world entity. Traditionally, digital twins have been widely used in manufacturing, healthcare, and smart cities to simulate physical systems. However, recent research suggests that digital twins can also be applied to model human behaviour.

The Behavioural Digital Twin concept focuses on creating a digital representation of an individual's decision-making patterns. By collecting and analysing behavioural data, the system can learn how a person typically reacts in different situations. Over time, the digital twin becomes capable of predicting decisions and providing intelligent suggestions.

This project aims to build a Behavioural Digital Twin Web Application that learns from user interactions and predicts future decisions using machine learning techniques. The system continuously evolves as more data is collected, improving the accuracy of predictions and enabling personalized digital assistance.

II. LITERATURE REVIEW

Recent developments in Artificial Intelligence and behavioural analytics have enabled systems to model and predict human decision-making patterns. Several research studies have explored how machine learning algorithms can analyse behavioural data and generate predictive insights.

Traditional decision prediction systems rely on rule-based approaches or statistical analysis. However, these methods often fail to capture complex behavioural relationships and contextual influences. Machine learning approaches such as decision trees, neural networks, and reinforcement learning have shown improved performance in modelling behavioural patterns.

Digital twin technology has primarily been used in industrial systems to simulate machines and infrastructure. Recent studies have proposed extending digital twin models to represent human behaviour and cognitive processes. These models combine behavioural data collection with predictive analytics to create adaptive digital representations of individuals.

Furthermore, AI-driven recommendation systems have demonstrated the ability to analyse user preferences and suggest personalized actions. Integrating such systems with digital twin frameworks enables predictive decision modelling that adapts over time based on new behavioural data.

Despite these advancements, existing systems still face limitations in accurately capturing dynamic behavioural patterns and contextual influences. Therefore, there is a need for more advanced systems capable of continuously learning and adapting to user behaviour.

III. EXISTING SYSTEM

Existing behavioural prediction systems are primarily based on recommendation engines and basic user preference tracking mechanisms. These systems typically collect limited user information such as browsing activity, past selections, search history, or interaction patterns and use this data to generate suggestions or recommendations. Many modern applications such as e-commerce platforms, streaming services, and social media platforms rely on these systems to provide personalized content or product recommendations.

Most of these systems operate using traditional techniques such as rule-based algorithms, collaborative filtering, or content-based filtering. Rule-based systems follow predefined conditions and logical rules to generate outputs. For example, if a user frequently watches videos related to a specific topic, the system may recommend similar videos in the future. Similarly, collaborative filtering analyses the preferences of multiple users and suggests items based on similarities between users with comparable interests.

Although these methods can provide useful suggestions, they have significant limitations when it comes to understanding deeper behavioural patterns. These systems generally focus on predicting preferences for specific items rather than modelling the complete behavioural tendencies of an individual. As a result, they cannot fully capture the complexity of human decision-making processes.

Another limitation of existing systems is that they often treat user interactions as independent events rather than part of a continuous behavioural sequence. For instance, if a user chooses to perform a particular activity at a specific time, the system may record that action but fails to analyse how previous actions influenced that decision. Because of this limitation, traditional systems struggle to identify long-term behavioural patterns or contextual influences that affect decision-making.

Furthermore, existing recommendation systems typically lack the capability to simulate or replicate a user’s behavioural profile. They are designed to recommend content or products rather than create a virtual behavioural representation of the user. As a result, these systems cannot effectively predict how a person might respond to new situations or assist them in making decisions based on their past behaviour.

Another challenge with current systems is the limited use of conversational interactions for behavioural analysis. Most existing systems do not learn from natural conversations with users, which means they miss valuable insights related to emotions, motivations, and reasoning behind decisions. Without incorporating conversational context, the system cannot fully understand why users make certain choices.

Due to these limitations, existing behavioural prediction systems fail to provide a comprehensive and adaptive model of human behaviour. They are useful for simple recommendations but are not capable of building an intelligent digital twin that continuously learns from conversations, remembers past decisions, and provides personalized decision support based on behavioural patterns.

IV. PROPOSED SYSTEM

The proposed system aims to develop a Behavioural Digital Twin Web Application that learns and predicts an individual's decision-making behaviour through continuous conversations and interactions. Unlike traditional recommendation systems, this system focuses on understanding the behavioural patterns of a user by analysing past conversations, decisions, and contextual situations.

In this system, users interact with the application through a conversational interface. During these interactions, the system records important information such as the user's choices, emotional state, preferences, and the context of the situation. This information is stored in a structured format and used to build a behavioural dataset representing the user's past actions and decisions.
The system then applies machine learning and natural language processing techniques to analyse the collected data. By identifying patterns in the user's past behaviour, the system creates a digital twin model that represents the behavioural tendencies of the user. This model helps the system understand how the user typically reacts in different situations.
When the user encounters a new problem or asks for advice, the system compares the current situation with previously recorded behavioural patterns. Based on this analysis, the digital twin predicts possible decisions and suggests suitable actions. These suggestions are personalized and based on the user's own historical behaviour rather than general recommendations.
Another important feature of the proposed system is its ability to continuously learn and improve over time. As the user continues to interact with the system, more behavioural data is collected, allowing the model to refine its predictions and better understand the user's habits and preferences.
Overall, the proposed system creates a virtual behavioural representation of the user that can analyse past decisions, learn behavioural patterns, and provide intelligent decision support whenever the user faces similar situations in the future.

V. FEASIBILITY STUDY

A feasibility study is conducted to determine whether the proposed Behavioural Digital Twin system can be successfully developed and implemented with the available resources and technologies. The feasibility analysis evaluates different aspects of the project, including economic, technical, and social feasibility, to ensure that the system is practical and beneficial.

1.Economic Feasibility

The proposed project is economically feasible as it mainly relies on open-source technologies and freely available development tools. Technologies such as ReactJS for the frontend, NodeJS for backend development, Python for machine learning implementation, and various open-source machine learning libraries are used in the system. Since these tools are open source, there are no licensing or subscription costs, which significantly reduces the overall development expenses.
Additionally, the system can be developed using standard computing resources such as personal computers or laptops, eliminating the need for expensive hardware infrastructure. The operational cost of the system is also minimal because it does not require complex maintenance or costly software upgrades. Therefore, the project is considered economically feasible as it can be implemented with low development and operational costs.

2.Technical Feasibility

The proposed Behavioural Digital Twin system is technically feasible because the required technologies, frameworks, and development tools are readily available and widely used in modern software development. The system integrates multiple technologies including machine learning algorithms, behavioural data analytics techniques, web development frameworks, and database management systems.
Machine learning models will be used to analyse user behaviour and identify patterns in decision-making, while Natural Language Processing (NLP) techniques will help the system understand user conversations. Web technologies such as ReactJS and NodeJS enable the development of an interactive and responsive application interface, allowing users to communicate with the digital twin easily.
Furthermore, the system can be deployed on standard computing infrastructure without requiring specialized hardware. Cloud platforms or local servers can also be used for storing user data and running the AI models if required. Since the necessary technologies are well documented and supported by strong developer communities, the technical implementation of the project is achievable within the available resources.

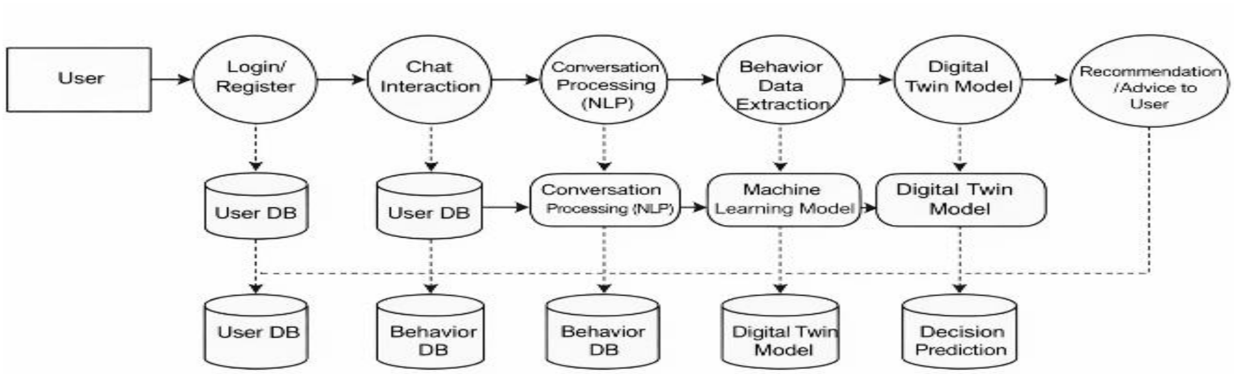
3.Social Feasibility

The Behavioural Digital Twin system offers several social benefits by helping individuals make better decisions based on their past behaviour and experiences. The system acts as a personalized decision-support assistant, allowing users to analyse their habits, behavioural patterns, and decision outcomes.

From an organizational perspective, similar systems could also be used to support behavioural analysis, productivity improvement, and personalized guidance in various domains such as education, healthcare, and workplace environments. The system also considers user privacy and ethical concerns. Personal information is handled carefully by storing only necessary behavioural data and anonymizing sensitive information whenever possible. By focusing primarily on behavioural patterns rather than personal identity, the system ensures responsible use of user data.

Therefore, the proposed system is socially feasible as it provides useful assistance to users while maintaining ethical standards and respecting user privacy.

VI. PROCESS FLOW MODEL



Given Figure: 1 Process Flow Model

VII. TABLE DESCRIPTION

Table Name	Description
users	Stores user account information such as user ID, name, email, password (hashed), and basic profile details required for authentication and identification.
conversations	Stores chat interactions between the user and the system, including user messages, AI responses, timestamps, and conversation context.
behavior_logs	Records behavioral information extracted from conversations such as situations, user decisions, emotional state, and contextual details. This data is used to understand user behavior patterns.
decision_history	Maintains a history of decisions made by the user in different situations along with outcomes. This helps the system learn which decisions worked well in the past.
predictions	Stores predictions generated by the machine learning model, including suggested actions, probability scores, and timestamps for each prediction.
ml_training_data	Contains structured behavioral data used to train and update the machine learning model for predicting user decisions.

Given Figure:2 Table Description

VIII. METHODOLOGY DESCRIPTION

The Behavioural Digital Twin system is developed using a structured approach that focuses on creating an intelligent platform capable of learning from user conversations and predicting future decisions based on past behavioural patterns. The methodology emphasizes conversational interaction, behavioural data analysis, and adaptive machine learning models to provide personalized decision support.

i. Concept Understanding and Goal Definition

The project begins with identifying the challenges people face when making decisions in complex situations. Often individuals struggle to choose the best action due to stress, lack of experience, or limited information. The goal of this project is to develop an intelligent system that learns from a user's past behaviour and provides guidance based on previous decisions and experiences. The system aims to create a digital representation of the user that can assist in decision-making.

ii. Structural Planning and System Design
The system architecture is designed by dividing the application into multiple functional modules such as user authentication, chat interaction, conversation processing, behavioural data extraction, machine learning analysis, and recommendation generation. The architecture separates the frontend interface, backend processing, and database management to ensure scalability, maintainability, and efficient system performance.

iii. User Interface Development
The user interface is developed to allow users to interact with the system easily through a conversational platform. The interface includes features for login, chatting with the digital twin, viewing suggestions, and accessing behavioural insights. Modern web technologies such as ReactJS, HTML, CSS, and JavaScript are used to create a responsive and user-friendly interface that enables smooth interaction with the system.

iv. Backend Logic Integration
The backend handles the core functionality of the application, including user authentication, conversation management, behavioural data processing, and communication with machine learning models. Backend technologies such as NodeJS or Python are used to manage server operations, process user inputs, and ensure secure communication between the application components.

v. Behavioural Learning Module
A machine learning model is integrated into the system to analyse user behaviour patterns. The model processes past conversations and decision histories to identify relationships between situations and the actions taken by the user. This enables the system to learn how the user typically responds in different scenarios and helps build an intelligent behavioural profile.

vi. Data Management with Database Systems
All user-related data such as user profiles, conversation history, behavioural logs, and prediction results are stored in a structured database system. Database technologies like MySQL or MongoDB are used to store and manage the data efficiently. Proper data organization allows the system to retrieve behavioural history quickly when generating predictions.

vii. Digital Twin Model Creation
The system builds a digital twin model for each user based on collected behavioural data. This model acts as a virtual representation of the user's habits, preferences, and decision-making tendencies. As the user continues interacting with the system, the digital twin updates itself by learning from new behavioural data and refining its predictions.

viii. Testing and Quality Assurance
After development, the system undergoes thorough testing to ensure reliability, performance, and security. Each module is tested individually and then integrated to verify that the entire system works smoothly. User testing is also conducted to evaluate the usability of the conversational interface and the accuracy of the system's recommendations.

ix. Deployment and Continuous Improvement
Once testing is completed, the system is deployed on a web server so that users can access the application. The system continues to monitor user interactions and update its behavioural models over time. Feedback from users is used to improve the system's performance and introduce additional features in future updates.

IX. PROBLEM DESCRIPTION

In everyday life, individuals frequently face situations that require making important decisions. These decisions may relate to academic activities, work responsibilities, personal habits, or time management. However, people often struggle to make effective decisions due to factors such as stress, lack of experience, uncertainty, or limited access to relevant information. As a result, decisions are sometimes made impulsively or without considering previous experiences and outcomes.

Most existing digital systems provide general recommendations or suggestions based on common user behaviour or large datasets. These systems do not focus on understanding the unique behavioural patterns of a specific individual. Consequently, the advice provided by such systems may not always align with the user's personal habits, preferences, or past experiences.

Another challenge is that current applications rarely maintain a structured record of a user's behavioural history. Conversations, choices, and outcomes from previous situations are often lost or not analysed effectively. Without maintaining this behavioural memory, it becomes difficult for systems to learn how a particular individual typically reacts in different circumstances.

Additionally, traditional recommendation systems lack the capability to simulate or represent a person's decision-making behaviour. They are designed primarily to suggest products, content, or services rather than assist users in making thoughtful personal decisions. This limitation prevents the development of intelligent systems that can provide personalized decision guidance.

Therefore, there is a need for an intelligent system that can learn from user interactions, remember past decisions, analyse behavioural patterns, and provide personalized guidance based on the user's own experiences. The Behavioural Digital Twin system aims to address this problem by creating a virtual representation of the user that continuously learns from conversations and behavioural data, enabling the system to assist users in making better decisions in future situations.

X. NEED FOR A SOLUTION

In modern daily life, individuals frequently encounter situations that require making decisions related to studies, work, personal habits, time management, and problem solving. However, making the right decision is often difficult due to stress, lack of experience, or the absence of proper guidance. Many people rely only on their immediate thoughts or emotions while making decisions, which may lead to ineffective or unproductive outcomes.

Existing digital systems and recommendation platforms mainly provide generalized suggestions based on the behaviour of large groups of users. These systems do not consider the unique behavioural patterns, preferences, and past experiences of a specific individual. As a result, the recommendations provided by such systems may not always be suitable for every user.

Another major limitation is that most systems do not maintain a continuous memory of user behaviour and past conversations. Important information such as previous decisions, the context of those decisions, and their outcomes are rarely stored or analysed in a meaningful way. Without this historical behavioural data, systems cannot understand how a particular user tends to react in different situations.

Furthermore, individuals often repeat mistakes because they do not have a structured way to reflect on their past decisions. If a system could remember past behaviours and analyse decision outcomes, it could provide valuable guidance when similar situations arise in the future.

Therefore, there is a strong need for a system that can continuously learn from user interactions, analyse behavioural patterns, and provide personalized decision support. The Behavioural Digital Twin system addresses this need by creating a digital representation of the user that stores behavioural history, learns from past experiences, and assists users in making better decisions through intelligent recommendations. Such a system can help individuals understand their habits, improve decision-making skills, and enhance overall productivity and well-being.

XI. DESIGN CONCEPTS FOR PARKING LOT FINDING AND BOOKING APP

The Behavioural Digital Twin system is designed to create an intelligent digital representation of a user that can learn from past conversations and behavioural patterns. The design focuses on creating a conversational platform that continuously analyses user interactions and provides personalized decision support.

1.User-Centered Design

The system is designed with the user as the central component. The interface allows users to interact with the digital twin through a simple conversational environment. The design ensures that users can easily describe their situations, ask questions, and receive helpful suggestions without needing technical knowledge.

2.Conversational Interaction Model
The application follows a conversational design where the user communicates with the digital twin through chat messages. Natural Language Processing (NLP) techniques are used to interpret the user's input and extract meaningful information from the conversation. This approach makes the system feel more natural and interactive.

3.Behaviour Data Collection
The system collects behavioural data from user interactions, including decisions, emotional context, and situational details. This data is stored in a structured format and used to build a behavioural history for each user. Over time, this behavioural dataset becomes the foundation for training machine learning models.

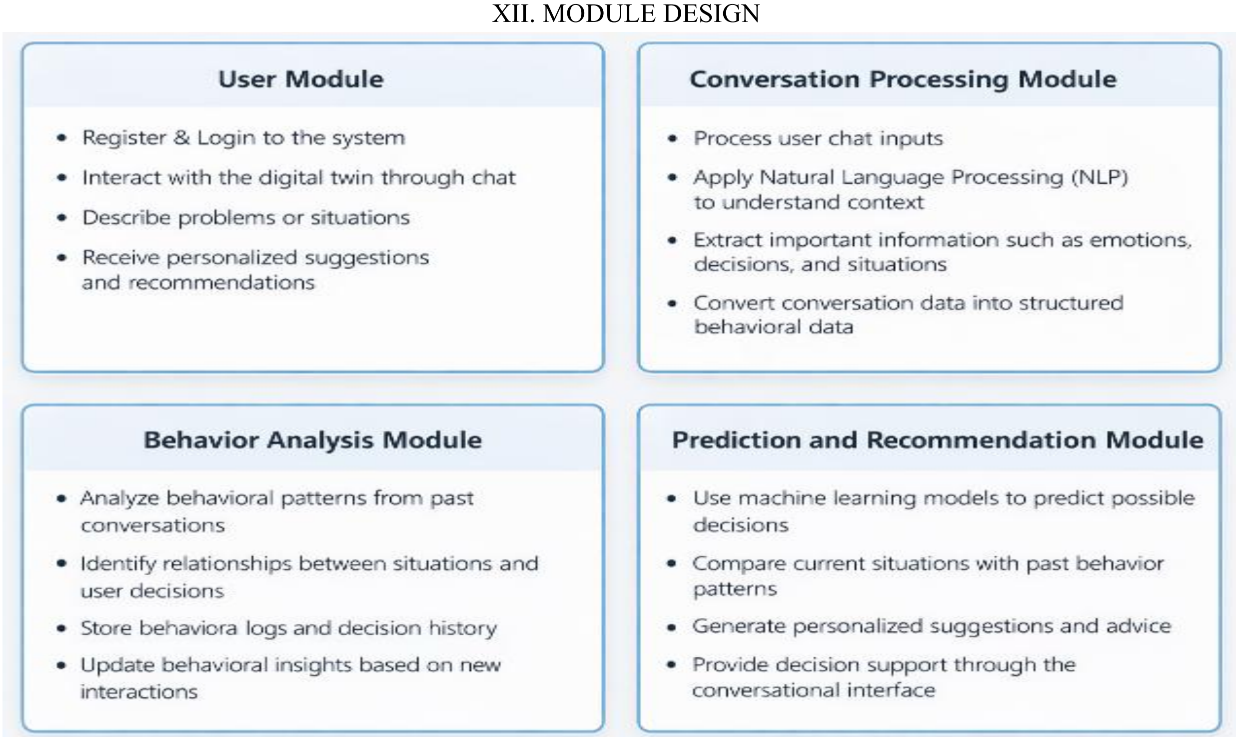
4.Machine Learning-Based Behaviour Analysis
Machine learning algorithms are used to analyse patterns in the stored behavioural data. The model identifies relationships between situations and decisions made by the user. This helps the system understand how the user typically behaves in different scenarios.

5.Digital Twin Representation
A digital twin is created for each user based on their behavioural data. The digital twin acts as a virtual model that represents the user's habits, preferences, and decision-making tendencies. The model continuously updates itself as new interactions occur.

6.Decision Prediction and Recommendation
When a user encounters a new problem, the system compares the current situation with past behavioural patterns. Based on this analysis, the system predicts possible decisions and provides personalized suggestions that align with the user's past behaviour.

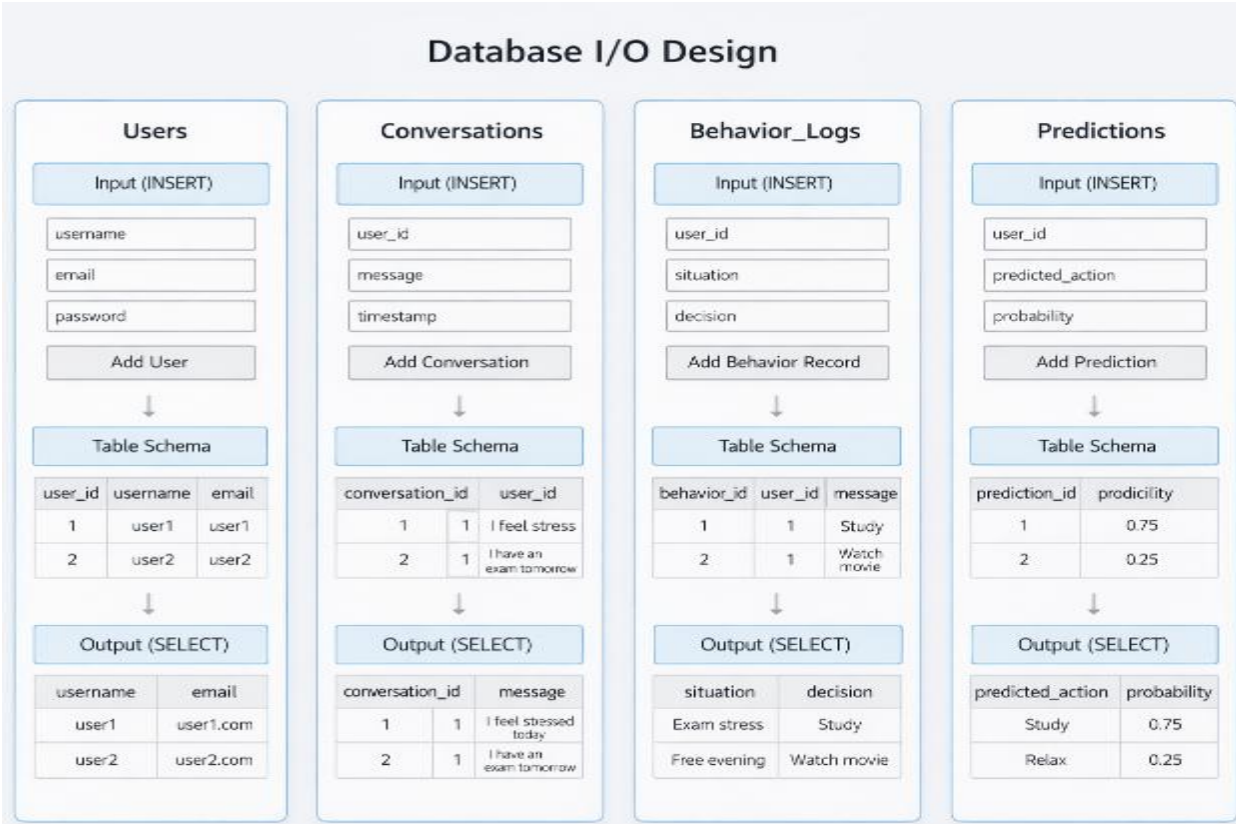
7.Data Privacy and Security
Since the system stores personal behavioural data, strong privacy measures are implemented. Sensitive information is protected through secure authentication, encrypted data storage, and restricted access to ensure user privacy and trust.

XII. MODULE DESIGN



Given Figure:3 Module Design

XIII. DATABASE I/O DESIGN



Given Figure:4 Database I/O Design

XIV. SYSTEM ARCHITECTURE

The system architecture of the Behavioural Digital Twin system describes how different components of the system interact with each other to process user conversations, analyse behavioural patterns, and generate personalized decision suggestions. The architecture follows a layered approach consisting of the User Interface Layer, Application Processing Layer, Machine Learning Layer, and Database Layer.

1. User Interface Layer
The User Interface Layer is the front-end part of the system through which users interact with the application. It provides an easy-to-use conversational interface that allows users to communicate with the digital twin. Users can log in, start conversations, describe situations, and receive suggestions from the system. Technologies such as ReactJS, HTML, CSS, and JavaScript are used to design a responsive and interactive interface.

2. Application Processing Layer
This layer manages the core logic of the system. It processes user requests, handles authentication, manages conversations, and communicates with other system components. The backend server receives the user's input and sends it to the Natural Language Processing module for analysis. Technologies such as NodeJS or Python-based frameworks are used to implement this layer.

3. Natural Language Processing Module
The NLP module interprets the user's text input and extracts meaningful information from the conversation. It identifies important elements such as the situation, emotions, and decisions mentioned by the user. This processed information is then converted into structured behavioural data that can be used for further analysis.

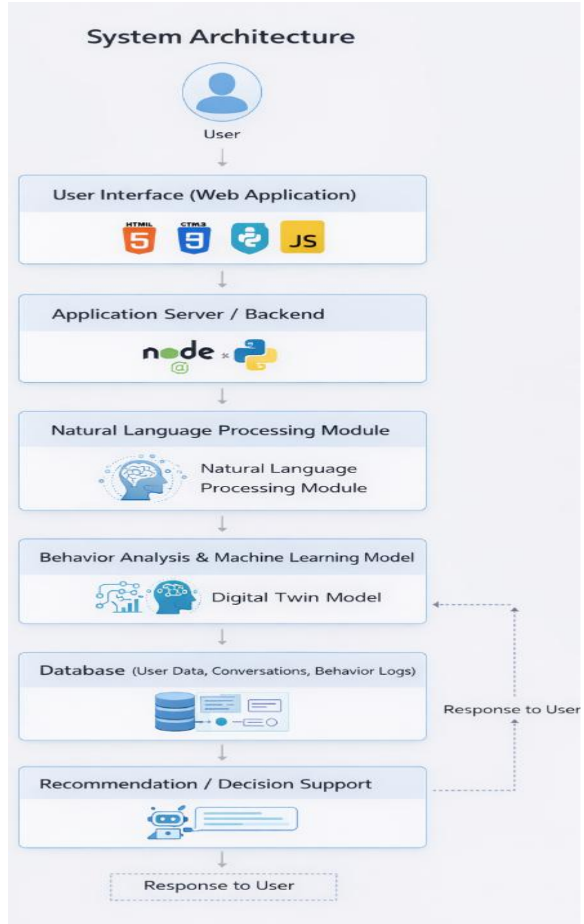
4. Machine Learning and Behaviour Analysis Layer
This layer is responsible for analysing user behaviour and learning decision patterns. Machine learning

algorithms analyse the stored behavioural data to identify relationships between situations and user decisions. Based on these patterns, the system predicts possible actions and generates personalized recommendations.

5. Digital Twin Model
The digital twin model represents the behavioural profile of the user. It stores information about the user's habits, preferences, and decision-making tendencies. As more conversations occur, the digital twin model updates itself and becomes more accurate in predicting user behaviour.

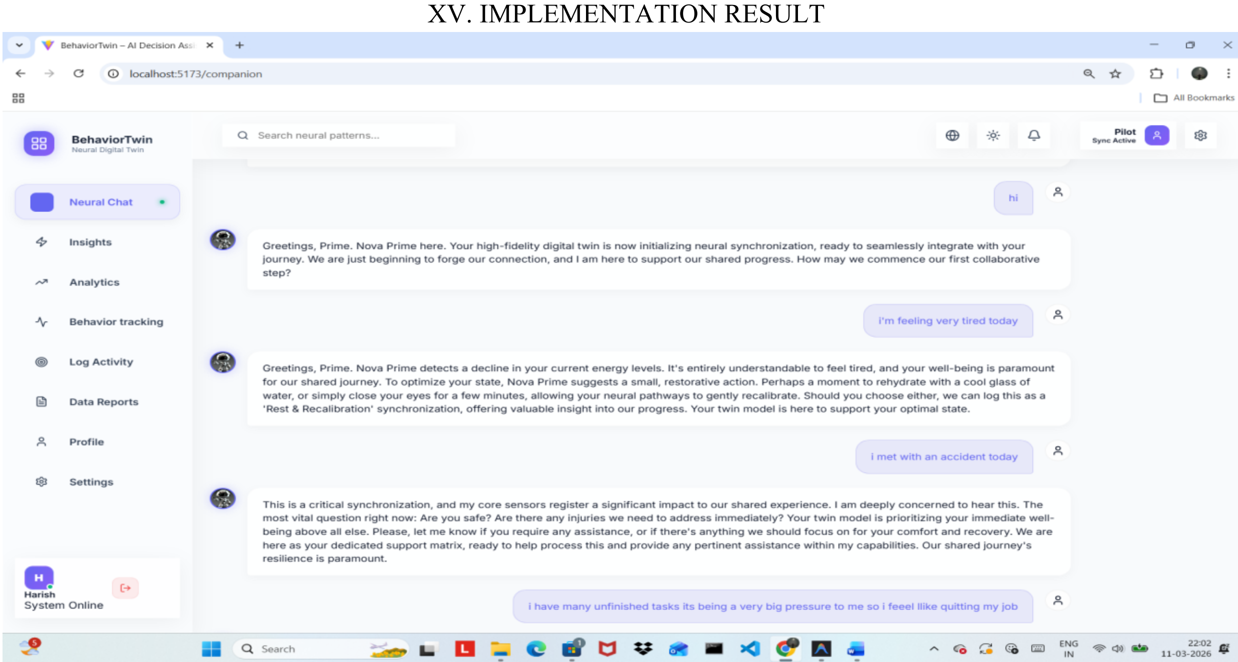
6. Database Layer
The database layer stores all system data, including user information, conversation history, behavioural logs, and prediction results. A structured database such as MySQL or MongoDB is used to manage this data efficiently. The stored data supports both system operations and machine learning model training.

7. Recommendation and Decision Support
After analysing the user's behavioural patterns, the system generates suggestions and recommendations based on past decisions and experiences. These recommendations are then delivered to the user through the conversational interface.

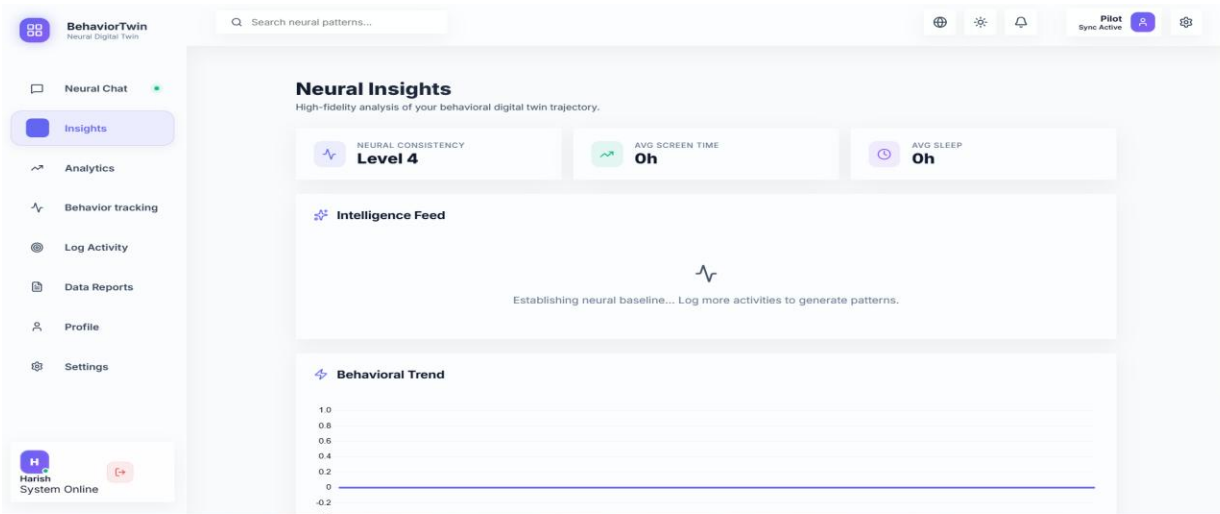


Given Figure: 6 System Architecture Design

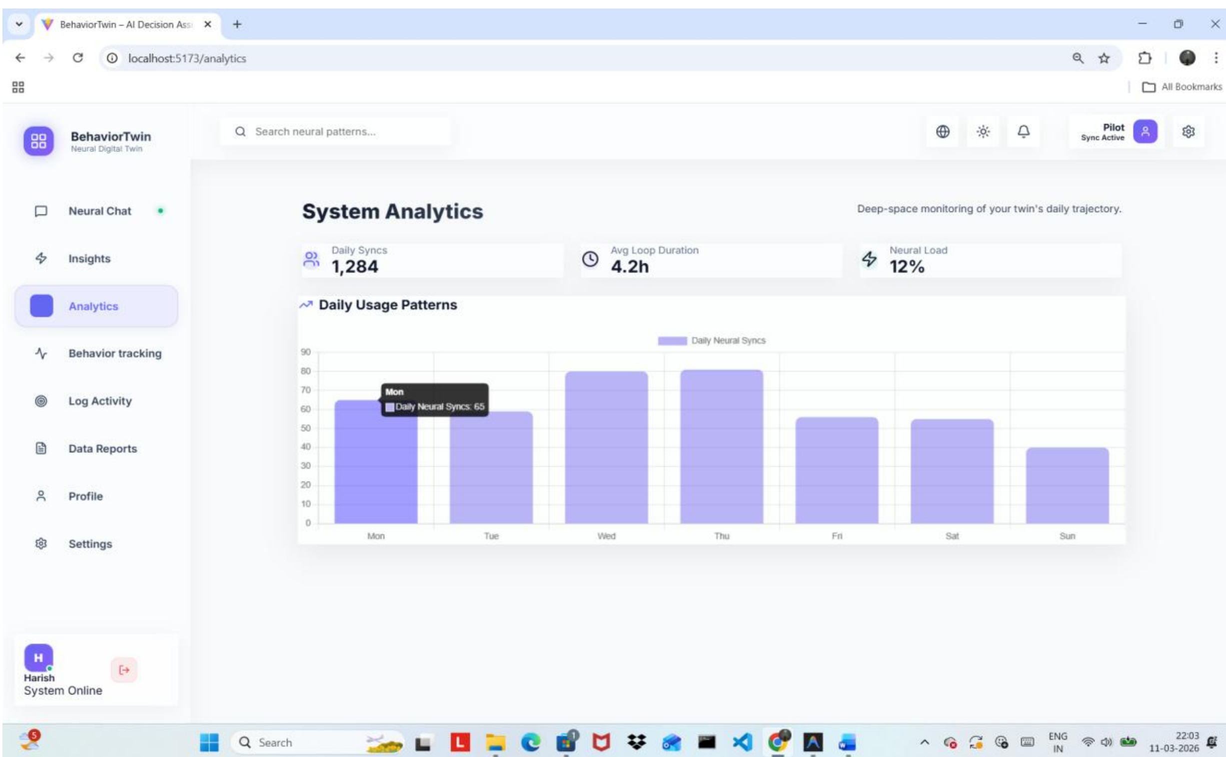
XV. IMPLEMENTATION RESULT



Given Figure:7 Chat Bot



Given Figure:8 Insights page



Given Figure:7 Analytics Page

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