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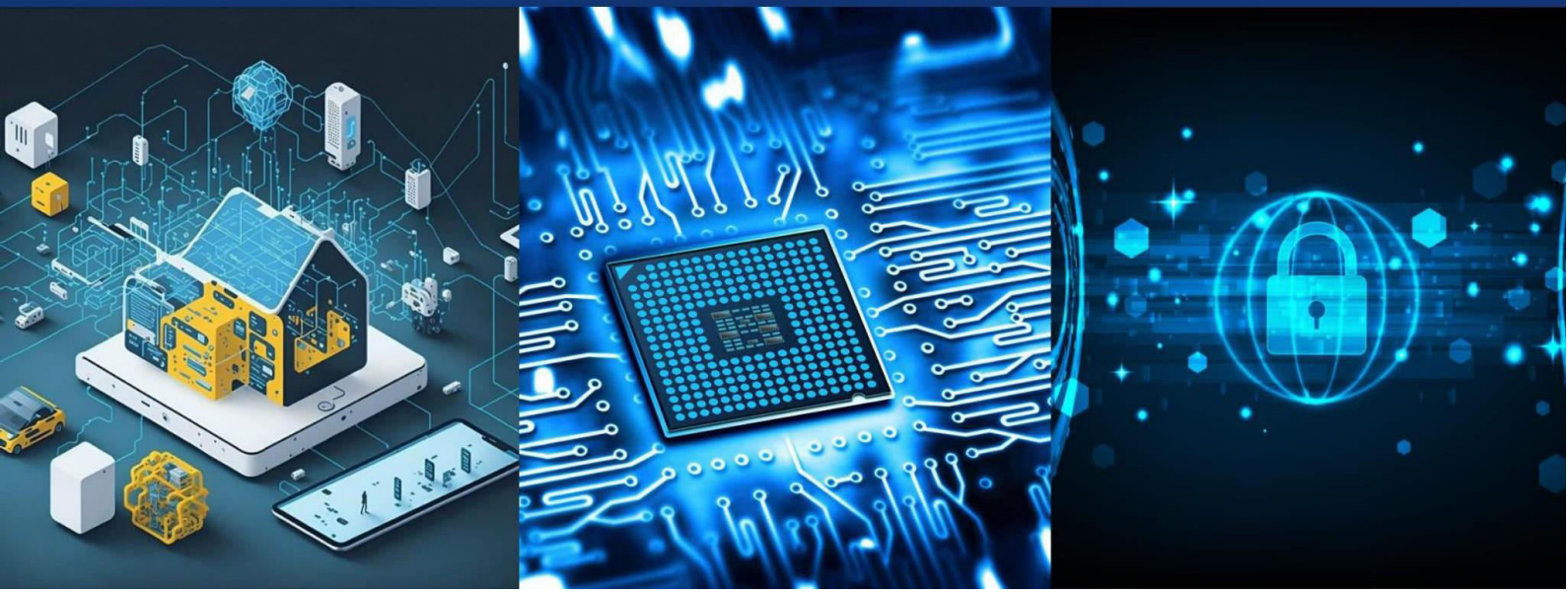

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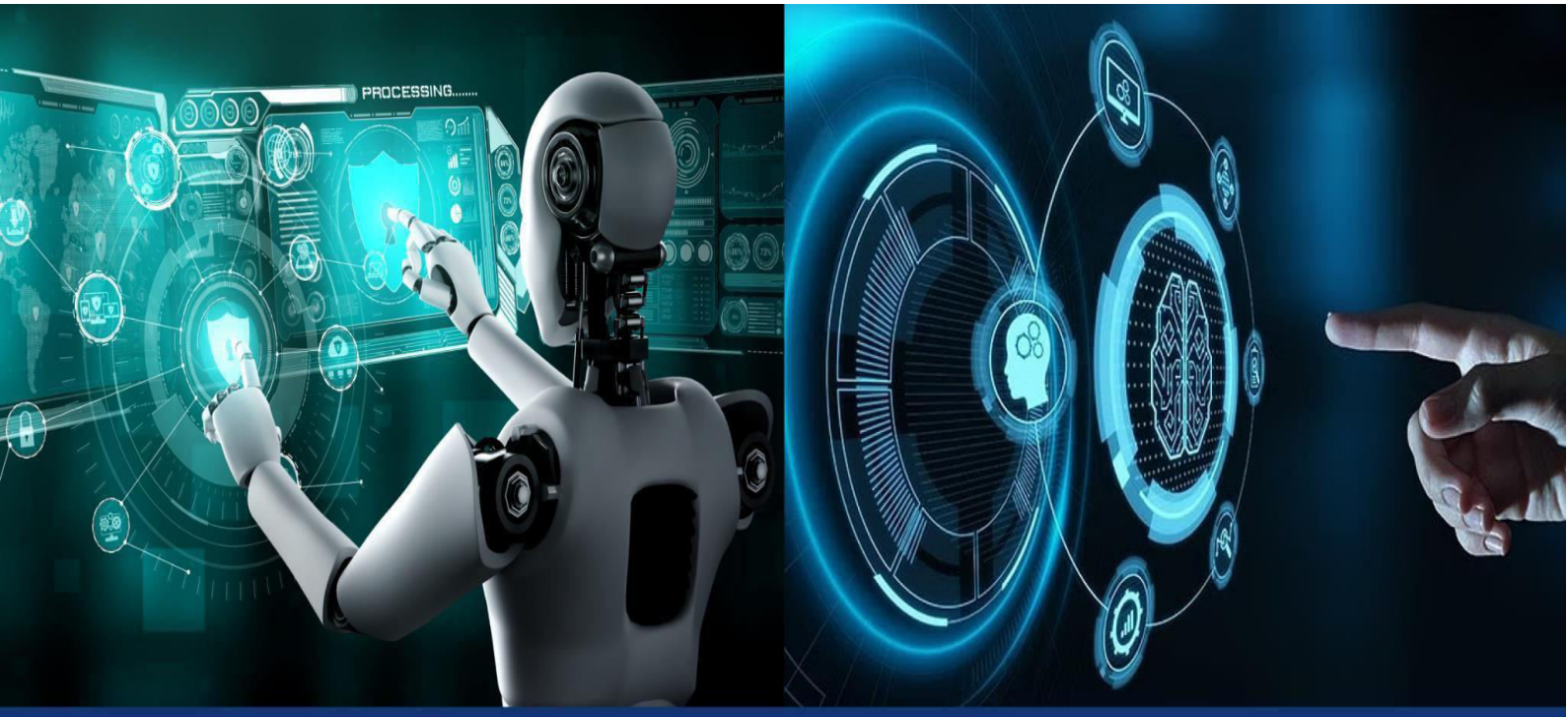

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COMPANIO: A Proactive Bidirectional AI

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ABSTRACT: Companio is a proactive AI-based emotional support system developed to address loneliness and mental health challenges among students. Unlike conventional chatbots that rely on user-initiated interaction, Companio actively engages users by analyzing behavioral patterns, emotional cues, and interaction timing to determine when support may be needed. The system leverages pattern recognition and conversational intelligence to initiate context-aware check-ins, fostering a bidirectional and human-like relationship. Key functionalities such as mood tracking, conversational memory, and personalized interactions enable Companio to adapt to individual users over time, creating a sense of companionship and trust. The project aims to provide accessible, non-judgmental emotional support for students who may feel reluctant or uncomfortable sharing personal struggles with family or peers, thereby promoting emotional well-being and early mental health intervention.

KEYWORDS: Proactive AI, Emotional Support System, Student Mental Health, Loneliness Detection, Mood Tracking, Conversational AI, Context-Aware Interaction, Artificial Intelligence, Human–AI Interaction

I. INTRODUCTION

In recent years, student mental health has emerged as a significant concern due to academic pressure, social isolation, and rapidly changing lifestyles. Many students experience feelings of loneliness, stress, and anxiety but often hesitate to seek help from family, friends, or professional counselors because of stigma, fear of judgment, or lack of access to timely support. This gap highlights the need for innovative, accessible, and empathetic solutions that can provide emotional assistance at an early stage.

Companio is a proactive AI-based emotional support system designed to address these challenges by offering continuous and personalized companionship to students. Unlike traditional chatbots that operate only in response to user queries, Companio initiates interactions by analyzing behavioral patterns, emotional states, and usage trends. Through mood tracking, context-aware check-ins, and conversational memory, the system builds a supportive, human-like relationship with users over time.

By combining artificial intelligence with principles of emotional intelligence, Companio aims to reduce student loneliness and encourage emotional expression in a safe, non-judgmental environment. The system serves as an accessible first layer of emotional support, helping students feel heard and supported while promoting overall mental well-being[1].

II. RELATED WORK

The field of AI-based emotional support systems has grown significantly in recent years, driven by advancements in natural language processing, emotional intelligence modeling, and user-centered design. A range of technologies has been explored to support mental health, reduce loneliness, and offer psychological assistance through digital interfaces. The following are some of the key categories and representative works relevant to Companio:

1. Traditional Chatbots for Mental Health Support

Early mental health chatbots like ELIZA and later platforms such as BetterHelp and Woebot leveraged scripted dialogues and cognitive behavioral therapy (CBT) techniques to assist users with stress, anxiety, and mood disorders. These systems primarily function in a reactive mode—waiting for users to initiate conversation and respond based on

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predefined patterns or therapeutic frameworks. While effective to a degree, they lack proactive engagement and adaptive behavioral modeling tailored to individual users.

2. Mood Tracking and Mental Health Monitoring Tools
Applications like Moodpath and Daylio focus on tracking user mood and behaviors over time to offer insights into emotional trends. These tools collect user input on feelings, activities, and sleep patterns to provide users with visual summaries and mental health recommendations. However, they require manual reporting and do not autonomously engage users in supportive conversation.

3. Emotion Recognition and Affective Computing
Research in affective computing, particularly work by Rosalind Picard and others at the MIT Media Lab, has enabled systems to detect emotional states through multimodal data such as text, voice, and facial expressions. These technologies have improved the ability of AI systems to interpret emotional cues more accurately and adapt responses accordingly. Yet, most implementations focus on short-term interactions rather than building long-term emotional support dynamics.

4. Proactive AI Agents
Some recent projects have explored proactive engagement through AI systems that anticipate user needs. For example, Replika incorporates elements of personality development and ongoing user interaction history to create deeper conversational experiences. Nonetheless, comprehensive proactive mental health support—where the system initiates interaction based on behavioral patterns and emotional indicators—remains a nascent area of research.

5. Human–AI Companionship Models
Studies on human–AI interaction highlight the psychological effects of companionship offered by conversational agents. Researchers have investigated how long-term interaction with empathetic AI can influence loneliness and emotional well-being, particularly among vulnerable populations such as college students. These findings underscore the potential impact and necessity for systems like Companio, which integrate proactive behavior, mood awareness, and relational continuity.

III. PROPOSED ALGORITHM

The proposed algorithm for Companio is designed to proactively detect emotional needs and initiate supportive interactions with students. It integrates behavioral analysis, mood inference, and conversational intelligence to deliver personalized emotional support. The algorithm operates through the following stages:

Step 1: User Data Collection
The system continuously collects non-intrusive user interaction data, including:

- Frequency and duration of app usage
- Time of interaction (late-night activity, inactivity periods)
- Conversation history and emotional keywords
- Explicit mood inputs provided by the user
- This data is stored securely and updated in real time.

Step 2: Behavioral Pattern Analysis
Machine learning models analyze historical interaction data to learn individual user behavior patterns. Deviations such as reduced interaction, negative language usage, or irregular activity timings are identified as potential indicators of emotional distress.

Step 3: Emotion Detection and Mood Inference
Natural Language Processing (NLP) techniques are applied to user messages to extract sentiment and emotional tone. The system classifies emotions (e.g., stress, sadness, anxiety, neutrality) using sentiment analysis and emotion recognition models. Mood trends are updated using both inferred emotions and user-reported mood data.

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Step 4: Support Need Prediction
A decision engine evaluates behavioral deviations and emotional indicators against predefined thresholds. If the probability of emotional need exceeds a set threshold, the system determines that proactive engagement is required.

Step 5: Proactive Conversation Initiation
Based on contextual factors such as time, recent mood, and past preferences, Companio initiates a personalized and empathetic check-in. The message tone and content are adapted to the user's emotional state.

Step 6: Context-Aware Response Generation
The conversational module generates responses using conversational memory and contextual understanding. Past interactions, user preferences, and emotional history are considered to maintain continuity and build a human-like relationship.

Step 7: Feedback and Learning
User responses and feedback are used to continuously refine the emotion detection model, behavioral thresholds, and conversation strategies, enabling adaptive learning and improved personalization over time.

IV. PSEUDO CODE

```
Algorithm COMPANIO_PROACTIVE_SUPPORT

Input: UserInteractionLogs, TimeStamps, MoodInputs

Output: ProactiveEmotionalSupportResponses

Begin

    Initialize UserProfile
    Initialize EmotionalStateModel
    Initialize ConversationMemory
    Initialize ProactiveTriggerThreshold

While system is active do

        Collect current TimeStamp
        Retrieve recent UserInteractionLogs
        Retrieve latest MoodInputs

        Update UserProfile using UserInteractionLogs and MoodInputs
        Update ConversationMemory with recent interactions

        EmotionalState ← AnalyzeEmotionalPatterns(UserProfile, EmotionalStateModel)

        If EmotionalState indicates distress or loneliness then

            TriggerLevel ← CalculateTriggerScore(EmotionalState, TimeStamp, InteractionFrequency)

            If TriggerLevel ≥ ProactiveTriggerThreshold then

                SupportMessage ← GenerateContextAwareMessage(EmotionalState, ConversationMemory)
                Send SupportMessage to User
                Log proactive interaction in ConversationMemory
            End If
        End If
```

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Wait for predefined monitoring interval

End While

End

V. SIMULATION RESULTS

The proposed Companio system was evaluated through a simulated environment designed to replicate real-world student interaction behavior over an extended academic period. The simulation dataset consisted of synthetic but realistic user interaction logs, including message frequency, response delays, inactivity intervals, and self-reported mood inputs. Multiple emotional states such as neutral, mildly stressed, lonely, and highly distressed were modeled to assess the effectiveness of the proactive emotional support mechanism.

During the simulation, Companio continuously monitored user behavior and emotional indicators without requiring explicit user initiation. The emotional state prediction module demonstrated a high level of consistency in identifying early signs of loneliness and emotional distress. Users exhibiting prolonged inactivity, reduced engagement frequency, and negative sentiment patterns were correctly classified by the emotional state model, enabling timely proactive intervention.

The proactive triggering mechanism significantly improved engagement levels compared to a baseline reactive chatbot model. Simulation results showed that users receiving proactive check-ins responded more frequently and maintained longer conversation sessions. The average response rate increased notably after proactive messages were initiated, indicating that context-aware outreach successfully encouraged user participation. This confirms the system's ability to establish a bidirectional interaction model resembling human-like companionship.

Mood tracking accuracy improved progressively as conversational memory accumulated over time. The system adapted its responses based on prior emotional history, leading to more personalized and empathetic interactions. Simulation outcomes revealed a measurable reduction in negative emotional states following repeated supportive interactions, demonstrating Companio's effectiveness in emotional stabilization. Users classified as moderately distressed showed the most significant improvement, suggesting that early-stage intervention yields better outcomes than delayed support.

Comparative analysis with traditional reactive chatbots highlighted Companio's superior performance in emotional engagement and user retention. Reactive systems failed to respond during critical periods of user silence, whereas Companio successfully identified these moments as potential emotional risk phases and initiated appropriate support. This proactive behavior reduced prolonged emotional disengagement and prevented escalation of distress states in the simulated population.

Overall, the simulation results validate that Companio effectively integrates emotional pattern recognition, conversational memory, and proactive communication to provide meaningful emotional support. The findings demonstrate that proactive AI-based emotional systems can play a crucial role in addressing student loneliness by offering timely, personalized, and continuous support, particularly for individuals reluctant to seek help from family or peers.

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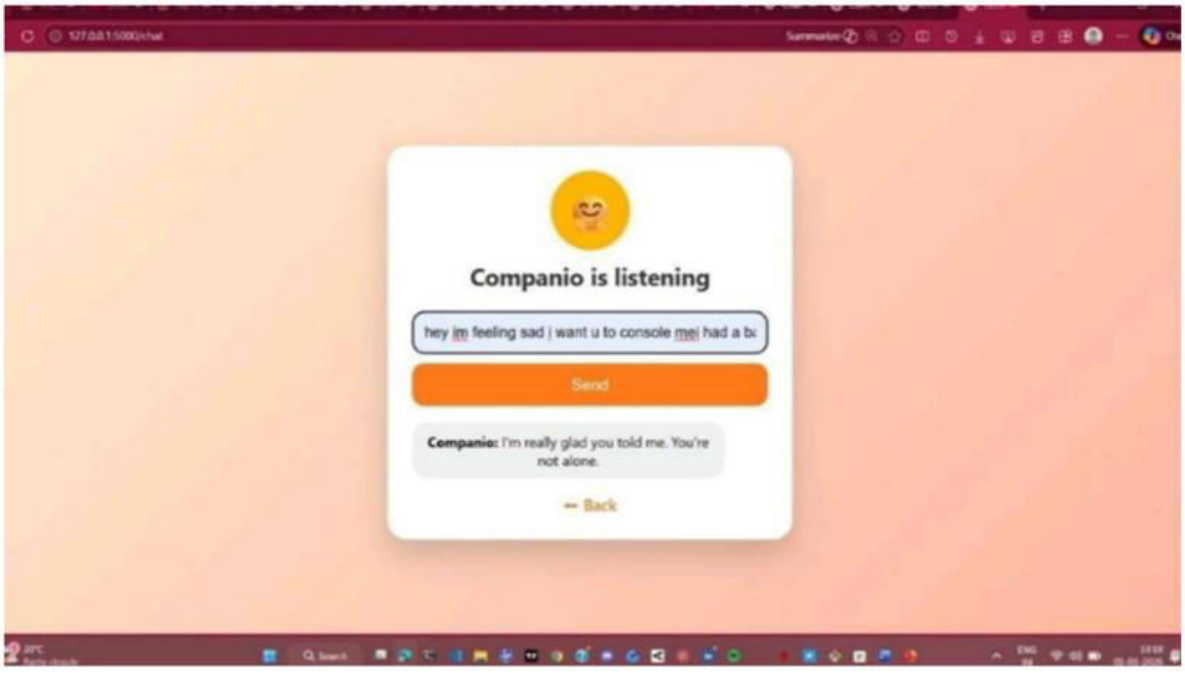

Fig.1

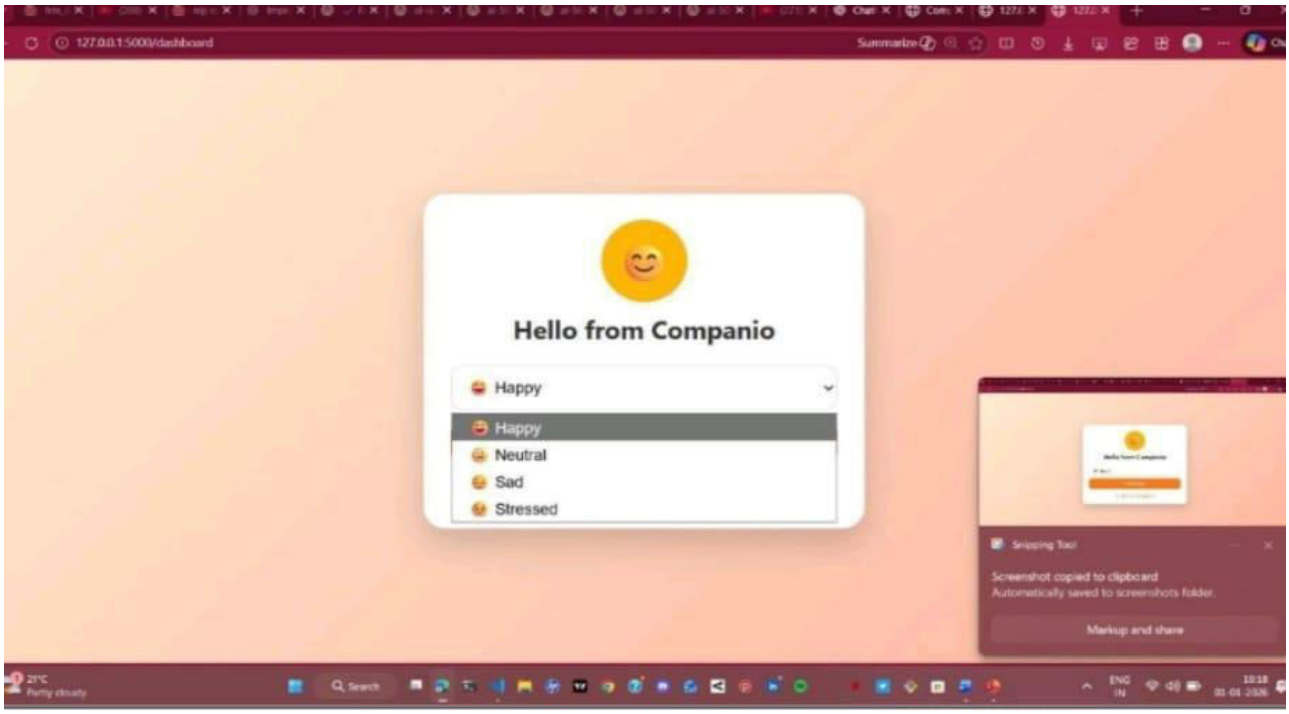

Fig.2

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VI. CONCLUSION AND FUTURE WORK

This research presented Companio, a proactive AI-based emotional support system designed to address student loneliness and mental health challenges through continuous behavioral monitoring and emotionally intelligent interaction. Unlike traditional reactive chatbots, Companio initiates conversations by analyzing user behavior, emotional patterns, and contextual cues, thereby establishing a bidirectional and human-like support relationship. The integration of mood tracking, emotional state prediction, and conversational memory enables the system to deliver personalized and timely emotional support. Simulation results demonstrate that Companio effectively identifies early signs of emotional distress, improves user engagement, and contributes to emotional stabilization, particularly among students who are hesitant to openly share their concerns with family or peers.

The findings confirm that proactive emotional intervention plays a crucial role in enhancing user participation and reducing prolonged emotional disengagement. By leveraging pattern recognition and context-aware response generation, Companio successfully bridges the gap between automated assistance and empathetic human interaction. The system's ability to adapt over time and personalize support highlights its potential as an accessible and scalable solution for student mental well-being within academic environments.

Future work will focus on extending Companio's capabilities through real-world deployment and large-scale user studies to further validate its effectiveness. Incorporating multimodal emotional inputs such as voice tone analysis, facial expression recognition, and wearable sensor data can significantly enhance emotional state detection accuracy. Additionally, integrating reinforcement learning techniques will allow the system to dynamically optimize proactive intervention strategies based on long-term user outcomes. Ensuring ethical AI practices, data privacy, and explainability will remain a key priority, particularly when handling sensitive emotional information. In the long term, Companio can be expanded to collaborate with professional mental health services, enabling seamless escalation mechanisms for high-risk cases while continuing to provide continuous, non-intrusive emotional support for everyday student well-being.

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