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Mapping Emotional and Cognitive Patterns of an Individual into Digital Simulations: A Survey

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***Abstract*—This presents an AI-powered personal simulation system that maps Emotional and Cognitive Patterns of an Individual Into Digital Simulations. The system continuously captures personal data through journaling and dynamic surveys enabling it to learn and recognize key cognitive and emotional patterns of the user. A similar architecture can be implemented when the use case extends to business, for aiding in product or idea testing. Applications spread across entertainment and busi- ness industries. The system preserves strong ethical boundaries and user control. By leveraging adaptive learning and real-time simulation, this system transforms AI into a digital extension of a human personality in terms of cognitive and emotional patterns.**

***Index Terms*—AI personal simulation, digital avatar, cognitive modeling, emotional modeling, adaptive learning, personalized AI, personalized feedback.**

I. Introduction

Existing AI Systems have enabled machines to mimic human interactions, but most of them are generic and cannot capture individuality of a person's emotional and cognitive patterns. Individuality is not seen in current Large Language Models. At the same time, there is growing interest in digital twins and personalized avatars across entertainment and business industries, where understanding an individual's cognitive and emotional patterns is crucial for meaningful interaction.

The motivation behind this project is to bridge this gap between existing generic AI chatbots and personalized AI, by building a system that continuously learns from the user and overtime, learns emotional and cognitive patterns of the user. The system is designed with respect to the privacy and ethical considerations. It ensures that the complete control of data lies with the user. This approach can be enhanced in the future by choosing Edge-Friendly frameworks. This approach enables the users to safely interact with the system and model a digital simulation of their emotional and cognitive patterns.

II. Literature Survey

A study by Raluca Budiu [1] - Digital Twins: Simulating Humans with Generative AI talks about how digital twins can be made and proposes two ways: A RAG model and a fine-tuning approach.

It provides its insights into how digital twins can be extended to UX testing as well. A systematic literature review by Lauer-Schmaltz et al. talks in detail about Human Digital Twins [2], highlighting the ambiguity that the definition holds. It talks on the dynamic nature of Human Digital Twins.

It proposes that there are 4 main types of HDTs namely - Human-in-the-loop HDTs that sees a person as a part of a bigger, generalized system, Physiological HDTs that focus on physical body, that include tracking things like heart rate, pulse etc, Mechanistic HDTs, that use math equations to understand dynamics of human body like blood flow and Cognitive HDTs that try to model a person's mind and are stated as a major leap from regular Digital Twins. Few major challenges are identified and grouped into three groups - Technical Problems that discuss about how complex and challenging HDTs can be, Trust and Understanding that reflects a fact that person has to trust the system in order to build their HDT and how it is necessary to white box the processing techniques and Ethical issues are also talked about. To solve all the challenges, an architecture that is modular, trustable and ethically viable is necessary. The solution must be understandable with an easy and intuitive user interface and components like visual avatar which can help people connect with it.

A study explores Human Digital Twins in the field of healthcare [3]. The process of building a human digital twin is studied. It consists of collecting data of the user like their health profile and creating a baseline model of the person. Data is continuously fed to the model. Tools like Machine Learning are recommended to predict the future health problems and to simulate how treatments might work on the person.

Data variation includes sources like Electronic Health records, Patient Generated Data, Environmental Data and Behavioural data including Social media data or Smart phone usage statistics. Complexities like integrating such variable data is talked about and concerns about ethical considerations are raised. It suggests that even though there is potential to make Human Digital Twins, a lot of work needs to be put into technical and ethical issues.

Another related study generalizes the concept of Digital Twin to a copy of real world object or system besides humans [4].

It states this innovation as a part of Industry 5.0 which focuses on sustainability, efficiency and human well-being. The technologies proposed are biological sensors like EEG and EMG to understand a person's physiological state, Artificial intelligence for making sense of all collected data and Machine Learning for predictions and training robots to learn from the environment. It also speaks about using AR/VR for testing purposes. It identifies the application potential of these digital twins including Testing robotic systems, education, product design etc.

Wang et.al discusses Human Digital Twin as a digital representation of human beings that has the potential to change the practice of human-system integration towards Industry 5.0 [5]. It talks about the HDT framework to contain three main components: human entity, virtual entity and an interactive system. The architecture contains 4 layers - agent layer, data layer, inference layer and implementation layer. Technologies discussed include data collection, computing, processing, representation, modeling and simulation. It also discusses extending applications to product customization and human-robot collaboration.

A systematic study focuses on Artificial Intelligence and digital twins. To address the problem of large amounts of data, AI simulation is used to generate synthetic data to train the AI model [6]. This paper introduces a reference framework called DT4AI which integrates digital twins and AI components for the purpose of simulation. AIML techniques are discussed, and among ML, Reinforcement learning is seen as the most widely used one.

A systematic literature review on the use of Artificial Intelligence within digital twins highlights that a digital twin requires physical-to-virtual connection or virtual-to-physical- connection [7]. Integrating AI such as ML and DL with digital twins can enhance the predictive capabilities and thus AI components can perform tasks like classification and forecasting based on the data provided. It compares various types of algorithms used including deep learning, reinforcement learning, and traditional ML algorithms in digital twins, depending on the specific task. It focuses on the fact that most of the data collected is not real-time and may compromise in terms of quality predictions. Overall it highlights that while AI is being integrated with digital twins, there are still gaps in terms of use of real-time data.

A study introduces a new system called HDTwin [8] that uses LLMs to create a digital twin of a person in terms of their cognitive health. The main goal is to enhance the accuracy of cognitive diagnoses by making use of diverse data on health such as Demographic data, Ecological Momentary Assessment (EMA) responses about mental sharpness, conducting n-back cognitive tests and speech/text data from journal entries.

The system combines all these different data sources into one unified model using an LLM allowing for a more comprehensive view of a person's cognitive health instead of relying on a single data source. From here diagnosis prediction is done using the integrated data to know if the persona has mild cognitive impairment (MCI) or is cognitively healthy. This approach performed well when compared to traditional machine learning classifiers by getting an accuracy of 0.77 on average where the baseline classifiers had an accuracy around 0.65. The plus point discussed here could be the explainability of the reasoning where it references the specific rules and patterns in the data that led to this conclusion.

An emotion-aware AI system [9] similar to digital twin has been proposed with the name Emotion-Aware Transformer encoder that highlights how transformers can be used in similar contexts. It highlights how conversational agents need to be emotionally intelligent to bond with the users and to generate responses that are empathetic. To do this the first stage that is implemented is an emotion detection module that predicts the user's emotional state using a LSTM-based classifier to categorize emotions into 8 groups. The encoder takes the predicted emotion and input utterance as inputs, word embeddings are generated and normalized and the encoder representation is passed into the Transformer-XL decoder to get the response. It achieved a BLEU-4 score of 0.225 when compared to other baselines which indicates that it generates good empathetic responses.

Discussion on how current AI systems fall short on learning one's preferences is done. It also talks about how human communication is not just about the words they use but also about the context and emotion [10]. To address this a chatbot called Diginality is introduced which uses HyperCLOVA X, an advanced LLm to learn individual preferences in emotional tone through a dialogue. The user starts by specifying their area of interest, based on which dynamic surveys are conducted and thus future responses are tuned to fit the conversational history. But still ethical concerns remain a key aspect to take care about.

A review investigates how Generative AI, especially Large Language Models are used for the development of digital twins or user personas across various domains [11]. It is concluded that there is a dominant use of GPT models where 82.7 percent use OpenAI's GPT variants. Overall, the data used is real, synthetic or a mix of both.

A systematic study uses algorithms like SVM, Random Forests, and boosting to infer users' Big Five personality traits from digital footprints [12] - for example, text, demographics, online behavior etc.

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The focus is on static personality predic- tion for applications like recommendations and advertising.

According to a systematic survey on the topic [7], a comparison between the algorithms has been made and it was found that deep learning is the most used algorithm.

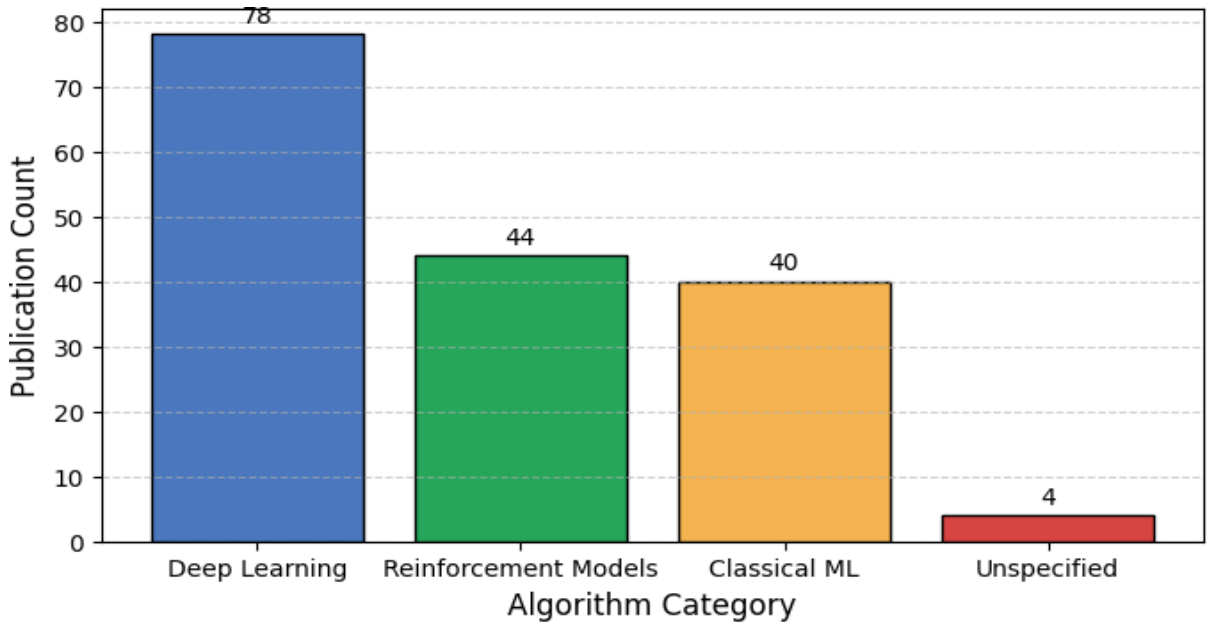

Fig. 5. Distribution of algorithm categories used in studies.

Fig. 1: Frequency of algorithms used [7].

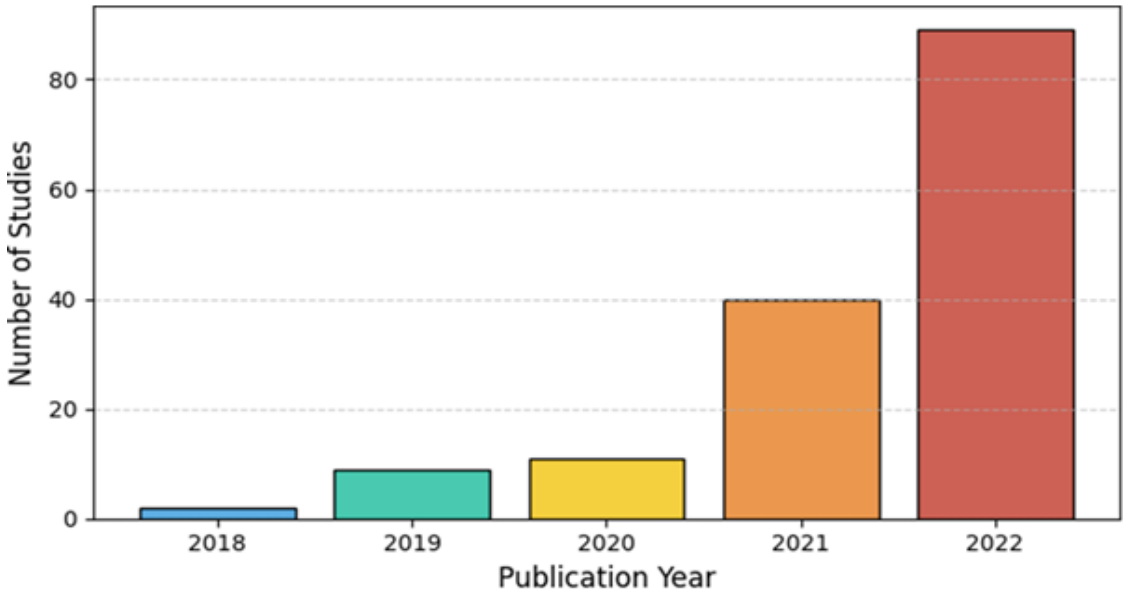

Fig. 3. Distribution of publications across different years.

Fig. 2: Frequency of publications [7].

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TABLE I:
Comparative analysis of related works

No.	Paper Title / Authors / Year	Key Points	Methodology
1	*Digital Twins: Simulating Humans with Generative AI* (Budiu, 2025)	Proposes RAG (Retrieval-Augmented Generation) and fine-tuning approaches for constructing digital twins; talks about application in UX testing	Conceptual framework; RAG and fine-tuning comparison; UX research application analysis
2	*Towards the Human Digital Twin: Definition and Design* (Lauer-Schmaltz et al., 2024)	Defines four HDT types: Human-in-the-loop, Physiologi- cal, Mechanistic, and Cognitive HDTs; proposes modular, trustable, ethically viable architecture and visual avatars	Systematic literature review; taxonomy development; architectural framework design
3	*Human Digital Twin: Data, Models, Applications, and Challenges* (Pan et al., 2025)	Presents healthcare-focused HDT framework involving data collection, baseline modeling, continuous data feeding, and ML-based health prediction; integrates EHR, patient-generated, environmental, and behavioral data	Healthcare-focused framework design; multimodal data integration; ML-based prediction modeling
4	*Human-Centric Digital Twins in Industry* (Asad et al., 2023)	Proposes Industry 5.0 oriented DT framework using biological sensors (EEG, EMG), AI/ML for data interpretation, and AR/VR for testing; applications in robotics, education, and product design	Comprehensive review; sensor-based data collection; AI/ML integration with AR/VR
5	*Human Digital Twin in the Context of Industry 5.0* (Wang et al., 2024)	Introduces HDT framework with 4 layers: agent, data, inference, and implementation; enables human-system integration for product customization and human-robot collaboration	Framework development; four-layer architecture design; Industry 5.0 context analysis
6	*AI Simulation by Digital Twins: Systematic Survey* (Liu & David, 2025)	Introduces DT4AI reference framework integrating digital twins with AI for synthetic data generation; concludes reinforcement learning as the most widely used ML technique	Systematic survey; DT4AI framework development; ISO 23247 mapping; 22 studies analyzed
7	*Artificial Intelligence in Digital Twins—A Systematic Literature Review* (Kreuzer et al., 2024)	A review of AI integration (ML/DL/RL) in digital twins for enhanced predictive capabilities; compares algorithms for classification and forecasting tasks across various industries	Systematic literature review; comparative algorithm analysis (ML/DL/RL); cross-industry examination
8	*Building a Human Digital Twin (HDTwin) Using LLMs* (Sprint et al., 2024)	Talks about HDTwin system using LLMs for cognitive health diagnosis; integrates demographic data, EMA responses, n-back tests, and journal text; achieves 0.77 accuracy outperforming baselines with 0.65	Algorithm development and validation; LLM integration; multimodal data fusion; accuracy benchmarking
9	*Emotion-Aware Transformer Encoder for Empathetic Dialogue* (Goel et al., 2021)	Proposes Emotion-Aware Transformer encoder with LSTM emotion detection module classifying 8 emotion types; uses Transformer-XL decoder for empathetic response generation; achieves BLEU-4 score of 0.225	Emotion detection module with LSTM; Transformer-XL decoder; BLEU score evaluation
10	*A Chatbot that Learns Preferences (Diginality/HyperCLOVA X)* (Yun et al., 2023)	Introduces chatbot named Diginality using HyperCLOVA X LLM; learns individual preferences through dynamic surveys and tunes future responses based on conversational history and emotional tone	Pilot study; LLM (HyperCLOVA X) implementation; dynamic survey-based preference learning

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Table I (Continued from previous page)

No.	Paper Title / Authors / Year	Key Points	Methodology
11	*How Is Generative AI Used for Persona Development* (Amin et al., 2025)	Review of 52 articles (2022–2024); Concluded 82.7% use GPT variants; Studies LLM usage into persona creation/enrichment, personalization, and validation	Systematic review (PRISMA); 52 articles from 6 databases (2022–2024); inter-rater reliability ($\kappa = 0.82$)
12	*Personality Prediction System Using Machine Learning* (Kenge et al., 2024)	Uses SVM, Random Forest, and boosting algorithms to predict Big Five personality traits from text, demographics and online behavior for recommendations and advertising	ML algorithm comparison (SVM, Random Forest, boosting); digital footprint analysis
13	*User Simulation in the Era of Generative AI* (2025)	Studies how LLMs mimic user behavior, generate synthetic data, and how systems work when real data is limited.	Review and analysis of user modeling, LLM-based simulation, and data generation techniques.
14	*Digital Twins and Generative AI: A Powerful Pairing* (McKinsey, 2024)	Studies how GenAI quickens twin creation and automation for analytics and customer experience.	Business case study and industry review on GenAI–DT integration.
15	*Impact of AI and Digital Twin Technology on Healthcare* (2025)	Highlights AI digital patient twins using biometric and health data for therapy and prediction.	Healthcare system review and predictive AI analysis.
16	*AI Avatars in Action: Applications, Challenges, and Future Potential* (GIJET, 2025)	Reviews how AI avatars use GenAI for interacting in conversational interfaces	Cross-sector literature review on avatar systems.
17	*Comprehensive Review of Digital Twins: Benefits, Use Cases, Challenges, and Future Directions* (2025)	Provides insights on AI and IoT integration in field of AT and summarizes them.	Systematic review (PRISMA); expert TRL evaluation.
18	*Digital Doppelgangers: Ethical and Societal Implications of Pre-Mortem AI Clones* (Methuku & Myakala, 2025)	Examines premortem and postmortem AI clones and talks about ethical concerns that arise in this field	Analysis of the premortem and postmortem AI clones based on AI governance, policy, and societal impact frameworks.
19	*Definitions and Characteristics of Patient Digital Twins Being Developed for Clinical Use: Scoping Review* (Drummond & Gonsard, 2024)	Through a review of existing studies, it defines what qualifies as a patient digital twin (PDT) and classifies their design and purpose for clinical usage.	Scoping review of 86 studies; literature mapping and classification of PDT frameworks and applications.

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TABLE II:
Research Gaps Identified and How They Are Addressed by the Proposed System

No.	Paper Title / Authors	AI/ML Techniques	Key Limitations	How Proposed System Addresses Gaps
1	*Digital Twins: Simulating Humans with Generative AI* (Budiu, 2025)	LLMs (GPT), RAG, fine-tuning	Static personas; no emotional evolution; ethical issues	Adds emotional awareness; ensures ethical control
2	*Towards the Human Digital Twin: Definition and Design* (Lauer-Schmaltz et al., 2024)	Conceptual (architecture-based)	Ambiguous HDT definitions; lack of emotional aspects	Defines cognitive and emotional pattern architecture
3	*Human-Centric Digital Twins in Industry* (Asad et al., 2023)	General AI/ML, AR/VR	Focused only on physical and cognitive data	Introduces emotional memory and relationship modeling
4	*AI Simulation by Digital Twins: Systematic Survey* (Liu & David, 2025)	Reinforcement Learning, ML, DL	Relies on synthetic data; lacks real-world personalization	Uses real user journaling and memory-based modeling
5	*Building a Human Digital Twin (HDTwin) Using LLMs* (Sprint et al., 2024)	LLMs (multimodal)	Focused on cognitive health only	Expands to emotional, relational, lifelong autobiographical modeling
6	*Emotion-Aware Transformer Encoder for Empathetic Dialogue* (Goel et al., 2021)	LSTM + Transformer-XL	Short memory; lacks personality evolution	Adds emotional and cognitive pattern awareness
7	*A Chatbot that Learns Preferences (Diginality/HyperCLOVA X)* (Yun et al., 2023)	HyperCLOVA X (LLM)	Surface-level preference modeling	Integrates moral boundaries and relationship awareness
8	*How Is Generative AI Used for Persona Development* (Amin et al., 2025)	GPT models (82.7%)	Static/synthetic personas; no personalization	Builds evolving digital twins with emotion and memory-based realism
9	*Personality Prediction Using ML* (Kenge et al., 2024)	SVM, Random Forest, Boosting	One-time classification; no emotional growth	Continuously adapts personality through emotional journaling

III. CONCLUSION

The survey done provides insights about various studies in the field of Digital twins. While the technology is actively evolving, many studies highlight the fact that ethical consider- ations and privacy issues must be worked upon seriously. The applications of digital twins range from healthcare, education to business and product design. The definition of a digital twin is not only limited to cognition but also the physiological aspects. The proposed system focuses on cognition based digital twin while keeping in mind, the ethical considerations.

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