Digital Self: The Next Evolution of the Digital Human

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Digital interactions are taking on a more human-like appearance and behavior, but could or should they become our digital selves?

Digital interactions have transformed how we conduct business, travel, communications, and entertainment. The interfaces for these interactions have evolved from holes punched into cardstock, to rudimentary touch-tone telephones, to the highly sophisticated smartbots of today. The human–machine interface will only continue to evolve, which brings up some interesting possibilities.

DIGITAL INTERFACES

First-generation digital interfaces were primarily focused on getting human requests or analog data into a binary electrical signal. In the earliest days of digital computers, commands and data were manually loaded directly into the processor via switches or jumpers. This cumbersome and error-prone mechanical interaction evolved into magnetic and punched paper tapes and cards enabling batch processing of many commands with multiple data points. These were eclipsed by increasingly sophisticated peripheral input and output devices such as keyboards, monitors, track balls, joysticks, and mouse, which all allowed interactive sessions between computer and user.

DIGITAL PERSONAS

The advent of artificial intelligence (AI) ushered in the second generation of digital interaction—the digital persona. Sound, text, or images entered through cameras, sensors, microphones, and devices were interpreted by writing, voice, and image recognition applications plus natural language processing and natural language understanding models. Business applications use these interpretations to generate responses that are returned to the user via natural language generation as textual data or, increasingly, as a synthetic voice. This interactive pipeline of smart input, smart processing, and smart output currently deliver an extremely nuanced digital persona.

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DIGITAL HUMANS

We are now realizing the emergence of third-generation digital interaction in which single-channel communications (for example, text in/text out or speech in/speech out) combine into a richer omnichannel model. We see speech and textual input augmented with gestures, facial expressions, tonal evaluation, sentiment analysis, context evaluation, and intent extraction to provide systems with more of the subtleties of human interaction than just the words. These enhanced input channels are processed by a combination of AI models and applications to derive responses and results. These AI models can now be hyperpersonalized in real time to learn, remember, and recall personal information and preferences to create highly contextual responses tailored for that individual user. Srini Pagidyala, cofounder of Aigo.ai explains, "We are extending the real-world user's brain into the digital world—what we call the *exocortex*. Our digital human is a personalized personal assistant that will take on the cognitive tasks of digital transactions on behalf of the user, freeing them up to spend time on more meaningful human activities."[1]

These responses are fed back to the user via a human-indistinguishable voice, complete with breathing, drag, vocal fry, filler clauses, subtle intonations, and emotives like laughter or sighs. When this synthetic voice is coupled with a lifelike facial or full-body avatar, with realistic articulated movement, appropriate gestures, and microexpressions, we have the digital human.

The use of digital humans is most prevalent in the gaming industry. Vladimir Mastilović, general manager of 3Lateral and vice president for digital humans technology at Epic Games, posits that, "We have been trying to reconstruct humans in a digital form since the first days of computer graphics. In creating copies of humans and giving them agency, we aim to recreate our physical presence in virtual worlds and express our identity. If you look at one of Epic Games' latest demo releases, *Matrix Awakens*, the experience shifts between a real-time rendered movie and an interactive experience in which we actively control the content, unlike a passive film. This merger of movie and game is not just science fiction like it was 10 years ago."[2]

We are highly sensitive to human faces. Emerging systems like the Facial Action Coding System provide a detailed understanding of the face and its movements and can even interpret facial variances, such as changes due to age.[3] However, current technologies cannot represent the evolution of a complete digital self because they cannot reconstruct a realistic "puppet" of a person in a particular time, either as they existed in the past or in the future (see Figure 1).

Mastilović notes that, "I still did not see tools capable of learning the full complexity of our behavior. We are still far from a self-operating, autonomous, and trustworthy digital self in a virtual space because human behavior is layered, unpredictable, and difficult to implement. So far, we have done some first steps toward the democratization of a digital human creation. For example, everyone can use our cloud-based MetaHuman Creator[4] to create a digital human animatable 3D asset in a web browser that can be later used in Unreal Engine."[2]

Nonetheless, the advent of digital humans does raise some ethical and social issues, including explainable AI and transparency. The technologies used for synthesizing and reproducing digital humans might make it challenging to discern between real human behavior and manipulated images and sounds. The absence of transparency into digital human behavior raises uncertainty as to how specific decisions are made and why particular actions were taken. The capacity of digital humans to explain their decisions to real users will be crucial to their adoption in many real-world situations.[5] Nonetheless, digital humans have been developed and deployed for a wide spectrum of applications for a growing variety of users,[6–8] making it essential to obtain clear and valid insights concerning their behavior on the following two levels:

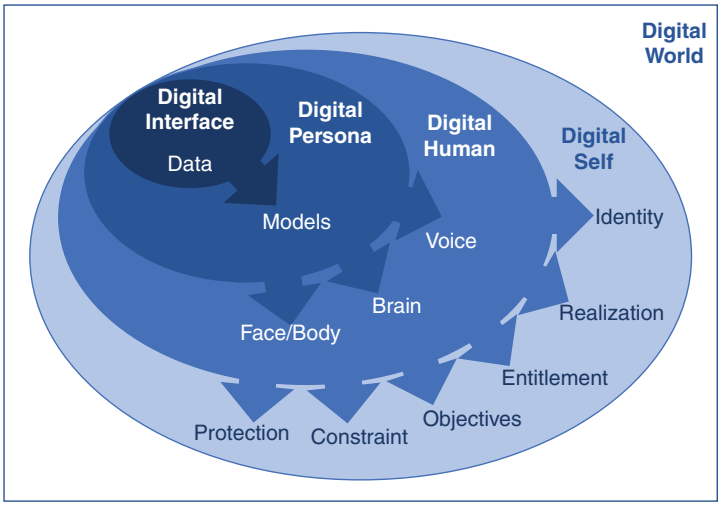

FIGURE 1. The evolution of the digital self.

1. *Implicit explainability* means behaving according to present social, cultural, ethical, and moral norms. Here, the reasons for the behavior are apparent due to constraints established by the norms; for example, a digital patient making a virtual appointment for a periodic visit to their personal (digital or real) doctor.
2. *Explicit explainability* denotes understanding more complex and contextual decision making for which an explanation is needed, such as the doctor clarifying his or her recommendation, diagnosis, or prescription to the patient.

DIGITAL SELVES

Beyond gamified movies, virtual assistants, and online agents where the user interacts with a digital human defined and controlled by the service provider, we see a trend toward digital humans who are defined and controlled by the user to further the users' own goals and objectives. For example, this "digital self" will describe symptoms and provide pertinent medical history to a doctor to receive a diagnosis or provide financial information to negotiate a bank loan that best meets the user's budget.

The democratization of digital identity is critical for the digital self. Tomorrow's solutions will provide all end users with the ready means to create, govern, replicate, and destroy their virtual-world counterparts. This will require the digital self to possess the following several well-defined attributes:

- *Realization*: a user-friendly framework will allow users to design, create, train, deploy, modify, and control a digital self.
- *Identity*: assigning the digital self a unique identifier and comprehensive metadata describing its capabilities, ownership, and relationship with other digital selves; this will allow it to be discovered, replicated, halted, and retired.
- *Entitlement*: providing the digital self with anticipated roles, behaviors, access, authorizations, rights, and privileges so it can act autonomously on behalf of its human owner.
- *Objectives*: a set of real-world priorities, obligations, goals, and targets that the digital self attempts to achieve through its decisions and actions.
- *Constraint*: a set of restrictions preventing the digital self from violating the owner's rights, obligations, laws, covenants, or ethics.
- *Protection*: a set of security measures that monitor, analyze, detect, notify, remediate, heal, and prevent harm toward, or by, the digital self.

DIGITAL WORLD

As digital selves evolve, they will need to interact with more than other digital selves. More nuanced behavior and interactions are possible if the digital self is immersed in a virtual world with its own geography, physics, and objects. One can imagine digital selves closing a mortgage and leaving a static, virtual bank lobby; walking through a virtual model home, discussing construction upgrades, and landscaping with the contractor; negotiating down payment options with the financier; and discussing quotes with three virtual insurance agents.

Launched in 2003, Second Life was the foremost pioneer in creating an entire virtual planet, complete with a digital topography, objects, people, currency, and one of the first virtual economies.[9] Today, gaming companies like Unity host a 5-cm resolution map of London and an interactive digital twin of a town in Germany.[10] Various digital worlds are under creation based on fictional worlds like Second Life, Generation Z, Ready Player One, and Roblox.[11] The union of these various worlds, dubbed the *Metaverse*, will undoubtedly coalesce in the coming years, and digital selves will have a larger ecosystem to continue their evolution.

AXES OF EVOLUTION

So how will digital humans evolve into digital selves? Digital humans have evolved from hype to practical usage over the previous decade. AI's algorithmic advancements, substantial increases in computational power, and the vast amounts of data generated at scale make digital humans a significant step forward in the gaming and film industries. However, we have yet to realize the digital self in everyday scenarios. Although the aforementioned attributes act as ultimate goals for the digital self, we can extract the following paths along which these goals must be satisfied:

- *Technology*: Today's AI technologies are dependent on massive data and computational horsepower to perform specific tasks. Tomorrow's real-time, mobile, and general-purpose digital self will require an evolved, artificial general intelligence with human-like fluid cognition and rapid learning from limited data.
- *Trust*: The spread of disinformation is ever-growing and hampering our ability to discern degrees of veracity. *Deep fakes* is an umbrella term for various technologies that could easily create and distribute realistic human faces online.[12] Therefore, developing and managing trust in the digital self requires standard metrics for trustworthiness, and methods for formal verification against certified standards. Currently, similar methods are pursued on the AI algorithmic level.[13]
- *Autonomy*: Digital humans employ algorithmic decision making, which, by its nature, is at high risk to violations of privacy, a lack of transparency and accountability, and biases

and discriminatory effects.[14] However, digital selves must operate autonomously in virtual environments, so their level of independence should balance customizability by their creators and personalization as learning from encounters with digital and real humans.

- *Humanness*: The common channels through which we perceive and interact with digital humans include text, vision/video, voice, and physiological.[6,7] Different verbal and nonverbal behaviors combine these modalities to provide a profound experience of (or immersion into) a real person. The major challenge is to make the modalities properly coherent and context dependent based on their current role. It is critical to avoid what some have dubbed the "uncanny valley" effect in which viewers are repulsed by even minor imperfections or deficiencies in representations of digital humans.[15]

DIGITAL ISSUES

A functional digital self will require the collaboration of diverse practitioners, such as artists, designers, developers, data scientists, psychologists, sociologists, philosophers, testers, lawyers, and domain experts. However, the development, deployment, and adoption of a digital self has several significant hurdles to clear before becoming commonplace, including

- *Form factors*: Although instances of digital humans and digital selves can be implemented using 2D devices like laptops and smartphones, this technology's natural progression would suggest a more immersive 3D deployment. However, we will need to develop a less obtrusive operational form factor than a head-mounted camera or wearables before we see widespread adoption.
- *Security*: How will the digital self's operations, information, and privileges be secured against compromise by bad actors? How difficult will it be to completely safeguard a digital self against threats and attacks.
- *Ethics*: Although digital selves will be a boon to digital users, they raise ethical and technical concerns. For example, would it be ethical for a person's digital self to refuse treatment upon receiving a diagnosis from a doctor, or make a large financial commitment based on an interaction with a financial advisor? Or would it be ethical for a digital self to act on behalf of a person who is incapacitated or deceased? One can imagine the digital self's autonomy will likely be limited to the user's abilities and expertise and include the human in the decision-making process.
- *Sovereignty*: Who "owns" the digital self? Is it the property of the user, the hosting platform, or the service provider? Can a subpoena be issued to acquire data, history, and content from the digital self, or does the human need to be notified?
- *Legal liability*: What happens if the digital self breaks the law or does harm? Can the human user be prosecuted if their digital self commits fraud, money laundering, or harassment? If a digital self goes rogue and sells your house, can you undo the transaction?
- *Persistence*: Digital selves will undoubtedly outlive their human counterparts. So what happens to digital selves after their users are incapacitated, rendered incompetent, or deceased? Can a digital self continue to act on behalf of their users to execute a will, manage a trust, complete long-term transactions, or make donations?

Undoubtedly, there are many other questions and issues that will emerge as digital selves are adopted.

From digital interfaces to digital personas to digital humans, user interactions with automated systems have become progressively more advanced and nuanced. We are on the cusp of the next step in this evolution—the digital self. We are only starting to imagine the advantages and utility these will bring to their users, but we have only just begun to visualize the issues that will need to be resolved before digital selves gain widespread use. We have met the enemy and, digitally, he is us. C

REFERENCES

1. S. Pagidyala, private communication, Jan. 21, 2022.
2. V. Mastilović, private communication, Jan. 14, 2022.
3. D. Monroe, "Digital humans on the big screen," *Commun. ACM*, vol. 63, no. 8, pp. 12–14, Aug. 2020, doi: 10.1145/3403972.
4. "MetaHuman creator: High-fidelity digital humans made easy," Epic Games, Cary, NC, USA, Jan. 20, 2022. Accessed: Jan. 20, 2022. [Online]. Available: https://www.unrealengine.com/en-US/metahuman-creator
5. S. Mohseni, N. Zarel, and E. D. Ragan, "A multidisciplinary survey and framework for design and evaluation of explainable AI systems," *ACM Trans. Interactive Intell. Syst.*, vol. 11, nos. 3–4, pp. 1–45, Dec. 2021, doi: 10.1145/3387166.
6. I. Ahmed, V. J. Harjunen, G. Jacucci, N. Ravaja, T. Ruotsalo, and M. Spape, "Touching virtual humans: Haptic responses reveal the emotional impact of affective agents," *IEEE Trans. Affective Comput.*, early access, Nov. 16, 2020, doi: 10.1109/TAFFC.2020.3038137.
7. D. Aneja, R. Hoegen, D. McDuff, and M. Czerwinski, "Understanding conversational and expressive style

in a multimodal embodied conversational agent," in *Proc. 2021 CHI Conf. Human Factors Comput. Syst.*, New York, NY, USA, pp. 1–10, doi: 10.1145/3411764.3445708.
8. W. Zhao, L. Xiongyi, T. Qiu, and X. Luo, "Virtual avatar-based life coaching for children with autism spectrum disorder," *Computer*, vol. 53, no. 2, pp. 26–34, Feb. 2020, doi: 10.1109/MC.2019.2915979.
9. P. Kariuki, "Could second life make a comeback as we head into the metaverse?" MakeUseOf.com, Jan. 18, 2022. https://www.makeuseof.com/second-life-metaverse-comeback/
10. C. D'Anastasio, "Gaming giant unity wants to digitally clone the world," *Wired*, Jan. 21, 2022. [Online]. Available: https://www.wired.com/story/gaming-giant-unity-wants-to-digitally-clone-the-world/
11. S.-M. Park and Y.-G. Kim, "A metaverse: Taxonomy, components, applications, and open challenges," *IEEE Access*, vol. 10, pp. 4209–4251, Jan. 2022, doi: 10.1109/ACCESS.2021.3140175.
12. S. Karnouskos, "Artificial intelligence in digital media: The era of deepfakes," *IEEE Trans. Technol. Soc.*, vol. 1, no. 3, pp. 138–147, 2020, doi: 10.1109/TTS.2020.3001312.
13. J. M. Wing, "Trustworthy AI," *Commun. ACM*, vol. 64, no. 10, pp. 64–71, Oct. 1, 2021, doi: 10.1145/3448248.
14. B. Lepri, N. Oliver, and A. Pentland, "Ethical machines: The human-centric use of artificial intelligence," *iScience*, vol. 24, no. 3, p. 102,249, 2021, doi: 10.1016/j.isci.2021.102249.
15. M. Masahiro, K. F. MacDorman, and N. Kageki, "The uncanny valley [From the Field]," *IEEE Robot. Autom. Mag.*, vol. 19, no. 2, pp. 98–100, 2012, doi: 10.1109/MRA.2012.2192811.

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