



Preservation of Human Essence: A Technological Evolution of Identity

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Abstract

The preservation of human essence in robotics represents a groundbreaking confluence of neuroscience, artificial intelligence and advanced sensory technologies. This article explores how cognitive continuity, emotional simulation, sensory perception and memory preservation contribute to maintaining individuality and human identity within robotic entities. Neural mapping digitizes thought patterns, algorithms replicate emotional responses and advanced sensors emulate human senses. Ethical considerations surrounding consent and equitable access are crucial to this transformative journey. By enabling humanity to transcend biological limitations, this approach redefines identity and legacy in a technologically evolved world.

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Introduction

The Earth's biosphere, a complex and dynamic system, is currently facing unprecedented threats due to anthropogenic activities. Factors such as habitat destruction, climate change, pollution and overexploitation of natural resources and the introduction of invasive species have resulted in significant biodiversity loss. This loss has far-reaching implications for ecosystem stability, food security and human health. For example, the disruption of ecosystems can lead to the emergence of zoonotic diseases, as evidenced by recent pandemics linked to wildlife ^[1, 2].

Biodiversity is essential for maintaining ecological balance, yet human actions continue to drive species extinction at an alarming rate, estimated to be 1,000 times higher than the natural background rate ^[3]. Such declines not only threaten ecological resilience but also jeopardize the myriad ecosystem services that support human life, including clean air, water and fertile soils. Furthermore, the alteration of global carbon and nitrogen cycles exacerbates the effects of climate change, creating feedback loops that further degrade biodiversity ^[4].

Simultaneously, humanity's aspirations to explore and inhabit extraterrestrial environments have necessitated innovative solutions for survival beyond Earth. Among these solutions, the concept of "robo-life" has emerged as a pivotal approach. Robo-life refers to the integration of robotic systems and artificial intelligence (AI) with biological components to create adaptive and autonomous systems capable of sustaining life in hostile environments, such as outer space ^[5, 6]. These systems can mimic or augment biological processes, including oxygen production, waste recycling and nutrient generation, making them indispensable for long-term space missions and colonization efforts ^[7].

The essence of humanity, encompassing cognitive, emotional and sensory experiences, defines individuality and forms the foundation of personal identity. As technological advancements push the boundaries of what it means to be human, the integration of these core attributes into robotic systems emerges as a pivotal area of exploration. Preserving human essence through robotics, neuroscience and artificial intelligence (AI) offers unprecedented opportunities to extend human capabilities and redefine the limits of existence.

Ray Kurzweil's vision of the singularity, where humans transcend biology through technological advancements, emphasizes the potential for robotics and AI to enhance human legacy^[9]. Similarly, Max Tegmark^[10] highlights the transformative role of Life 3.0—a stage where humans and machines coexist seamlessly, offering new dimensions of intelligence and adaptability. These perspectives align with recent developments in neural mapping, emotional algorithms and sensory systems, which enable robotic entities to emulate and preserve human characteristics.

Cognitive continuity, achieved through neural mapping technologies, ensures the digitization of complex thought patterns and decision-making processes^[11]. Emotional simulation, as detailed by Hanson *et al.*^[12], leverages algorithms to replicate empathy and social interaction, bridging the gap between humans and robots. Additionally, advancements in sensory perception allow robots to exceed human limitations, processing tactile, auditory and visual stimuli with unprecedented precision^[13].

Despite these advancements, ethical considerations play a critical role in this transformative journey. Bostrom^[14] and the IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems emphasize the importance of ensuring consent, equitable access and the ethical integration of hybrid entities. These principles guide the responsible evolution of technologies that preserve human essence, ensuring that innovation aligns with societal well-being.

The intersection of biodiversity conservation and robo-life development presents an intriguing frontier. Technologies inspired by natural systems, such as bio-mimetic designs and bioengineered habitats, could offer novel solutions to both terrestrial and extraterrestrial challenges. For instance, leveraging the genetic diversity of extremophiles—organisms that thrive in extreme environments—may inform the creation of resilient biotechnological systems for space survival^[15].

This manuscript explores the dual challenges of biodiversity conservation and the advancement of robo-life systems. By examining the threats to Earth's ecosystems alongside the potential of robotics and bioengineering for space exploration, we aim to highlight synergies that could address pressing global and extraterrestrial needs.

Cognitive Continuity

Cognitive continuity refers to the preservation of thought patterns, decision-making abilities and intellectual traits that define an individual. Achieving this in robotics requires sophisticated neural mapping technologies capable of digitizing the intricate workings of the human brain. These technologies replicate neural pathways, enabling robotic systems to process information, reason and adapt in ways that align with human cognition.

Neural Mapping Technologies

Neural mapping involves creating a digital representation of the brain's structure and functions. Using advanced imaging techniques like functional MRI (fMRI) and magnetoencephalography (MEG), researchers can map neural activity with high precision (Russell & Norvig, 2020)^[11]. Machine learning algorithms then analyze this data to create models of thought processes and decision-making frameworks. These models can be encoded into robotic systems, ensuring the preservation of cognitive traits such as creativity, problem-solving and adaptability.

Preservation of Intelligence

Preserving intelligence goes beyond simple data transfer. It involves capturing the dynamic interplay of reasoning, intuition and memory. For instance, AI systems integrated with neural maps can adapt to new situations, draw connections between seemingly unrelated concepts and make decisions based on incomplete information—hallmarks of human intelligence (Kurzweil, 2005)^[9]. This capability enables robots to function autonomously while retaining the essence of human thought.

Enhancing Decision-Making Capabilities

By digitizing human cognition, robotic systems can inherit decision-making capabilities that are both logical and empathetic. This is particularly valuable in high-stakes environments, such as space exploration, healthcare, or disaster response, where quick and accurate decisions are critical. For example, robotic surgeons equipped with cognitive continuity systems could make nuanced decisions during complex procedures, blending technical precision with human-like reasoning.

Applications in Problem-Solving

The ability to solve problems creatively is a key aspect of cognitive continuity. Robotics powered by neural mapping can approach challenges with human-like ingenuity, generating innovative solutions that address real-world issues. For instance, robots in research environments can replicate the cognitive processes of scientists, accelerating discoveries in fields ranging from material science to medicine.

The Role of Memory Integration

Cognitive continuity is closely tied to memory integration. Digitizing personal memories allows robotic systems to access an individual's experiences, preferences and knowledge base. This not only preserves individuality but also enhances the robot's ability to respond to familiar contexts and make informed decisions (Tegmark, 2017)^[10].

Challenges in Cognitive Continuity

While the potential is immense, challenges remain in achieving true cognitive continuity. The complexity of the human brain, ethical concerns surrounding identity replication and technical limitations in neural mapping present significant hurdles. Furthermore, questions about ownership and control of digitized cognition need to be addressed, ensuring that these systems respect the autonomy and rights of individuals.

Implications for Humanity

The preservation of cognitive continuity opens up new possibilities for humanity. It enables individuals to transcend biological limitations, extending their intellectual legacy into mechanical systems. This not only enhances individual potential but also allows humanity as a whole to thrive in environments previously deemed uninhabitable, from deep-sea habitats to interstellar missions.

By ensuring cognitive continuity, robotics and AI pave the way for a future where human intellect and creativity remain central to technological evolution, preserving the unique essence of humanity for generations to come.

Emotional Simulation

Emotional simulation involves the replication of human emotional responses within robotic systems, enabling them to exhibit empathy, curiosity and social interaction. This capability is vital for preserving the relational and affective aspects of human essence, bridging the gap between human and robotic entities. By leveraging advanced algorithms and neural models, robotic systems can mimic emotional responses and facilitate meaningful interactions.

Algorithms for Emotional Replication

The foundation of emotional simulation lies in algorithms designed to replicate neural activity associated with emotions. Drawing inspiration from affective neuroscience, these algorithms model the brain's limbic system, responsible for generating and regulating emotions. Machine learning techniques analyze vast datasets of human expressions, vocal tones and physiological signals to identify patterns and generate responses that align with emotional states.

For instance, sentiment analysis tools can interpret text or speech to determine emotional intent, while deep learning models can process facial expressions and body language to infer underlying feelings. These insights allow robots to respond appropriately, creating an illusion of empathy and emotional understanding.

Empathy and Social Interaction

A key element of emotional simulation is the ability to exhibit empathy, the capacity to understand and share another person's feelings. Robots achieve this through emotional alignment, where their simulated responses mirror the emotional cues of humans they interact with. For example, a care robot in a healthcare setting could recognize signs of distress in a patient and offer comforting words or actions, enhancing the quality of care.

By programming robots to engage in social interactions, researchers ensure they can navigate complex interpersonal dynamics. Robots equipped with emotional simulation are being used as companions for the elderly, educators for children and even mediators in conflict resolution. Their ability to simulate curiosity and maintain engaging conversations makes them valuable partners in social contexts.

Advanced Technologies for Emotional Realism

To ensure realism, robots incorporate a combination of hardware and software solutions that mimic human emotional expression. For instance:

- **Facial Mimicry:** Robots with dynamic facial actuators can simulate expressions like smiling, frowning, or surprise, mirroring human emotions in real-time.
- **Voice Modulation:** Speech synthesis systems adjust tone, pitch and cadence to convey emotions such as warmth or urgency.
- **Tactile Feedback:** Robots with haptic sensors can simulate comforting gestures like a gentle touch, reinforcing emotional bonds.

Applications of Emotional Simulation

Emotional simulation has found applications across various domains, including:

1. **Healthcare:** Robots with emotional intelligence support mental health therapies, offering companionship and reducing feelings of isolation.

2. **Customer Service:** Emotionally responsive robots improve customer interactions, creating positive experiences by addressing concerns empathetically.
3. **Education:** Robots designed as tutors use emotional cues to maintain student engagement and motivation.

Ethical and Psychological Considerations

The integration of emotional simulation into robotics raises ethical and psychological questions. Critics argue that simulated emotions, being artificial, might lead to a false sense of trust or emotional dependency on machines (Bryson, 2018) [13]. Additionally, concerns about the misuse of emotionally intelligent robots for manipulation highlight the need for clear ethical guidelines.

Balancing Emotional Authenticity

While achieving perfect emotional authenticity is challenging, the goal is not to replace human emotions but to create a complementary experience that resonates with human users. By simulating empathy, curiosity and social interaction, robots can foster trust and cooperation, making them more effective in roles that require emotional engagement.

Transforming Human-Robot Relationships

The ability to simulate emotions significantly enhances the role of robots in society, transforming them from mere tools to entities capable of meaningful interactions. This not only preserves the emotional essence of humanity but also expands the potential for collaboration between humans and robots, redefining the boundaries of emotional connection in the age of intelligent machines.

By developing sophisticated emotional simulation technologies, researchers and engineers are unlocking new ways to preserve and extend the human experience, ensuring that the emotional dimensions of human essence are not lost in the transition to a technologically advanced future.

Sensory Perception

Sensory perception in robotics focuses on replicating the human senses—touch, vision, hearing, smell and taste—using advanced sensors and algorithms. By recreating these sensory experiences, robots can interact with their environment in ways that closely mimic human perception, preserving an essential aspect of human essence. Enhanced sensory perception not only bridges the gap between humans and machines but also expands the capabilities of robotic systems beyond biological limitations.

Touch: Haptic Sensors and Tactile Feedback

The sense of touch is vital for human interaction with the physical world. Robots equipped with haptic sensors can simulate tactile sensations, enabling them to detect pressure, texture, temperature and even vibrations. For example:

- Piezoelectric and capacitive sensors measure changes in force and pressure, allowing robots to handle delicate objects with precision, such as picking up a fragile glass or interacting with biological samples.
- Tactile skin technologies, such as e-skin, provide robots with a distributed sensory network, mimicking the human ability to feel across their "body".

Robotic prosthetics and assistive devices use these technologies to restore the sense of touch for amputees,

enhancing their quality of life and creating a more seamless integration between human and machine.

Vision: Advanced Imaging and Perception

Robots replicate human vision using high-resolution cameras and computer vision algorithms, enabling them to perceive and interpret their surroundings. Unlike human eyes, robotic vision systems can operate across multiple spectral ranges, including infrared and ultraviolet, providing capabilities beyond human perception. Key advancements include:

- **Object Recognition:** Machine learning models trained on vast datasets allow robots to identify objects, faces and environments with remarkable accuracy.
- **Depth Sensing:** LIDAR and stereo vision systems enable robots to perceive depth, crucial for navigation and interaction in three-dimensional spaces.
- **Adaptive Vision Systems:** Algorithms mimic the human eye's ability to adjust focus and process motion, enhancing situational awareness in dynamic environments.

Applications include autonomous vehicles, where sensory perception ensures safe navigation and medical robots, which use enhanced vision for surgical precision.

Hearing: Adaptive Auditory Systems

Robotic hearing systems replicate human auditory perception using advanced microphones and sound processing algorithms. These systems enable robots to:

- **Recognize Speech:** Natural language processing (NLP) algorithms interpret spoken language, facilitating seamless communication.
- **Identify Sounds:** Audio pattern recognition systems distinguish environmental sounds, such as alarms or footsteps, providing contextual awareness.
- **Localize Audio Sources:** Beamforming and spatial audio techniques allow robots to pinpoint sound sources, crucial for applications like search and rescue missions.

For instance, humanoid robots use auditory systems to engage in conversations, while industrial robots use them to detect anomalies in machinery.

Smell: Olfactory Sensors

Although less common, olfactory sensors mimic the human sense of smell by detecting chemical compounds in the air. These sensors have applications in:

- **Environmental Monitoring:** Detecting hazardous gases or pollutants.
- **Food Safety:** Identifying spoilage or contamination in food products.
- **Healthcare:** Diagnosing diseases by analyzing breath samples for biomarkers.

Recent advancements in electronic noses (e-noses) have expanded the potential of robotic olfaction, enabling machines to perform tasks traditionally reliant on human olfactory perception.

Taste: Gustatory Sensors

The sense of taste is replicated using sensors that analyze chemical compositions, primarily for specialized applications like food quality assessment. For example:

- Robots in the food industry use gustatory sensors to

ensure consistent flavor profiles.

- Healthcare applications include dietary monitoring and the development of artificial tasting systems for medical research.

Multisensory Integration

The true power of sensory perception in robotics lies in the integration of multiple senses, enabling robots to process complex environmental stimuli. For instance:

- Robots with combined vision and touch can manipulate objects more effectively, such as identifying an object visually and adjusting grip pressure based on tactile feedback.
- Cross-modal learning algorithms allow robots to associate sensory data, like recognizing an object's texture and shape simultaneously, for enhanced interaction.

Expanding Beyond Human Capabilities

In addition to mimicking human senses, robots can extend perception beyond biological constraints. For example:

- Ultrasound sensing for medical imaging.
- Radiation detection for environmental safety.
- Thermal imaging for security and search operations.

These enhancements enable robots to perform tasks in hazardous or inaccessible environments, such as deep-sea exploration or space missions.

Implications for Preserving Human Essence

Replicating sensory perception ensures that robots can experience and interpret the world in ways familiar to humans, fostering better interaction and integration. It also allows individuals to extend their sensory experiences through robotic systems, preserving their unique sensory identity. For instance, an individual's sensory preferences could be digitized and integrated into a robotic system, enabling the continuity of their personal experiences.

Challenges and Ethical Considerations

While advancements in sensory perception have been significant, challenges remain, including:

- Ensuring data accuracy and avoiding sensory biases.
- Addressing privacy concerns in applications like auditory surveillance or visual recognition.
- Balancing sensory replication with ethical guidelines to prevent misuse, such as exploiting emotional responses through haptic interactions.

The replication and enhancement of sensory perception are pivotal in preserving the human essence within robotic systems. By combining advanced sensors, algorithms and multisensory integration, robotics can mimic human experiences while surpassing biological limitations. These advancements redefine human-robot interaction, ensuring that the sensory dimensions of humanity are not only preserved but also extended into new realms of possibility.

Memory Preservation

Memory preservation is a cornerstone of integrating human essence into robotic systems, focusing on safeguarding an individual's personal history, experiences and cognitive patterns. By digitizing and encoding memories, it becomes possible to maintain identity and continuity across biological

and mechanical domains. Memory preservation bridges the gap between human consciousness and robotics, allowing individuals to extend their legacy beyond physical limitations.

Digitization of Personal Memories

Digitizing human memories involves the use of advanced neuroimaging techniques and computational models to extract, analyze and store neural data. Techniques include:

- **Functional Magnetic Resonance Imaging (fMRI):** Captures brain activity related to memory recall, identifying neural patterns associated with specific experiences.
- **Electroencephalography (EEG):** Records electrical activity in the brain, providing insights into short-term memory processes and real-time thought patterns.
- **Brain-Computer Interfaces (BCIs):** Enable direct communication between the brain and computational systems, translating neural activity into digital data for memory storage.

Memory Encoding and Storage

Once digitized, memories are encoded into data formats that allow for efficient storage, retrieval and processing. This involves:

- **Semantic and Episodic Memories:** Separating memories into factual information (semantic) and personal experiences (episodic) for structured organization.
- **High-Capacity Databases:** Using cloud-based systems or advanced quantum computing technologies to store vast datasets of encoded memories securely.
- **Compression Algorithms:** Ensuring that memory data is stored efficiently without losing contextual richness, enabling seamless recall.

Real-Time Memory Integration

In robotic systems, preserved memories are integrated into frameworks that allow for dynamic interaction and decision-making. This involves:

- **Neural Emulators:** Simulating the brain's hippocampus to enable memory recall and context-aware responses.
- **Adaptive Learning Models:** Allowing robots to use preserved memories for situational understanding and personal growth. For example, a robotic companion can recall shared experiences with a human, fostering emotional continuity.

Memory as Identity

Preserved memories serve as the foundation for maintaining personal identity within robotic systems. Key aspects include:

- **Autobiographical Continuity:** Robots equipped with human memories retain the individual's sense of self, ensuring that their unique personality and history remain intact.
- **Cultural and Social Legacy:** Memories encapsulate cultural practices, beliefs and social interactions, allowing robots to act as custodians of collective human knowledge.
- **Emotional Context:** Memories are deeply tied to emotions, enabling robots to replicate emotional responses associated with specific experiences.

Applications of Memory Preservation

The digitization and integration of memories have far-reaching implications:

- **Posthumous Legacy:** Preserved memories allow individuals to leave behind a digital version of themselves, enabling loved ones to interact with their robotic counterpart.
- **Medical Interventions:** Memory preservation offers therapeutic applications, such as aiding individuals with neurodegenerative diseases by creating external memory prostheses.
- **Skill Transfer:** Complex skills and expertise can be preserved and transferred to robotic systems, ensuring continuity in fields like medicine, engineering and education.

Ethical and Privacy Considerations

Memory preservation raises critical ethical and privacy concerns, including:

1. **Consent:** Ensuring that individuals willingly share and digitize their memories.
2. **Data Security:** Protecting sensitive memory data from unauthorized access or misuse.
3. **Identity Ownership:** Addressing questions about who controls and benefits from preserved memories—individuals, corporations, or society.
4. **Authenticity:** Ensuring that digitized memories are accurate representations of the individual and not subject to manipulation or alteration.

Challenges in Memory Preservation

Despite technological advancements, challenges remain

- **Neural Complexity:** Human memories are encoded through complex and interdependent neural networks, making full digitization a significant technical hurdle.
- **Data Overload:** The vast amount of data generated by memory preservation demands innovative storage and processing solutions.
- **Ethical Governance:** Developing global frameworks to regulate the use and preservation of memories in robotics.

Future Prospects of Memory Preservation

Emerging technologies promise to enhance memory preservation further:

- **Artificial Neural Networks (ANNs):** Mimic human brain structures for more accurate memory modeling and integration.
- **Cryonics and Digital Immortality:** Combining physical preservation with digital memory storage to achieve comprehensive identity continuity.
- **Holographic Memory Systems:** Using holography to create immersive and interactive memory recall experiences in robotics.

Implications for Human Essence

Preserving memories ensures that an individual's essence—comprising their experiences, emotions and knowledge—is not lost with biological decline. By integrating memories into robotic systems, humanity can transcend physical boundaries, redefining concepts of life, identity and continuity in an increasingly technological world.

Memory preservation offers a profound means of maintaining human identity and legacy through the integration of personal experiences into robotic systems. By overcoming technical and ethical challenges, society can unlock the full potential of memory preservation, ensuring that the human essence endures in new and meaningful forms. This journey not only safeguards individuality but also reshapes our understanding of what it means to be human.

Ethical Considerations

The integration of human essence into robotics through advanced technologies such as neural mapping, memory encoding and sensory simulation raises profound ethical questions. These considerations are crucial for ensuring that such innovations align with societal values, protect individual rights and foster equitable access. Addressing these ethical dimensions is not only a moral imperative but also a practical necessity to ensure public trust and the responsible development of human-robot integration technologies.

Informed Consent

Ensuring informed consent is foundational to ethical practices in preserving human essence. Individuals must fully understand and agree to the processes of neural mapping, memory digitization and integration into robotic systems. Key elements include:

- **Transparency:** Providing clear explanations of the procedures, risks and potential outcomes.
- **Autonomy:** Allowing individuals the freedom to decide without coercion or external pressure.
- **Revocability:** Ensuring that participants can withdraw their consent and data at any stage of the process.

Privacy and Data Security

The digitization of human essence generates vast amounts of sensitive data, including memories, neural patterns and emotional responses. Protecting this data is paramount to maintaining individual privacy and preventing misuse. Measures include:

- **Data Encryption:** Using advanced cryptographic techniques to secure data during storage and transmission.
- **Access Control:** Limiting access to personal data to authorized personnel and systems.
- **Anonymization:** Removing identifiable information from datasets to prevent misuse.
- **Cybersecurity Frameworks:** Developing robust systems to safeguard against hacking and data breaches.

Identity and Ownership

As human essence is digitized and integrated into robotic systems, questions about the ownership of identity and memories arise. Key considerations include:

- **Individual Rights:** Ensuring that individuals retain ownership of their digitized memories and neural data.
- **Corporate Accountability:** Preventing corporations from exploiting human data for profit without consent.
- **Legal Protections:** Establishing laws that safeguard digital identities and ensure fair use.

Equity and Accessibility

The potential for preserving human essence must not be limited to a privileged few. Ethical considerations demand that these technologies be accessible to all, regardless of

socioeconomic status. Strategies include:

- **Affordable Solutions:** Developing cost-effective methods to make the technology widely available.
- **Global Access:** Ensuring that developing nations have equal opportunities to benefit from advancements.

Conclusion

Preserving human essence through robotics and AI offers an unprecedented opportunity to redefine identity and legacy. By integrating cognitive, emotional and sensory experiences into robotic systems, humanity can transcend biological limitations and explore environments previously deemed inaccessible. However, this transformative journey must be guided by ethical principles, ensuring responsible innovation and equitable access. As humanity advances toward this technologically evolved future, the preservation of human essence will serve as a cornerstone of progress.

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