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Bridging Human-Computer Interaction and Ecofeminism: Insights from Deleuze and AI

Wanjin Dong[1,2*], Soonbae Kim[2], Adam Slowik[3], Jianhui Lv[4]

Abstract

The rapid advancements in Artificial Intelligence (AI) and human-computer interaction (HCI) have profound implications for society. However, the integration of Ecofeminism and Deleuzian philosophy still needs to be explored in this context. While existing literature has separately examined HCI, Ecofeminism, and Deleuze's concept of "becoming-woman," there is a lack of interdisciplinary studies that bring these diverse perspectives together, particularly in AI and contemporary literature. This paper introduces a novel framework that integrates HCI, Ecofeminism, and Deleuze's "becoming-woman" to analyze AI technologies and literary works. We employ this interdisciplinary lens to critique and reimagine AI systems, advocating for more inclusive and ecologically responsible designs. We offer a comprehensive review of contemporary literature that engages with these themes, enriching the discourse in HCI and literary studies. Moreover, we integrate neural machine translation (NMT) models into interactive machine translation to propose a classical prefix-based NMT segment-based interactive protocol, i.e., the interactive NMT (iNMT) method. The positive impacts of such an iNMT method, when viewed through the lens of HCI, ecofeminism, and Deleuzian philosophy, lie in its potential to democratize interactions, amplify marginalized voices, and offer new tools and metaphors for exploring fluid identities in contemporary literature and beyond. Our findings reveal that incorporating Ecofeminist and Deleuzian perspectives can lead to more ethical and inclusive AI systems. Additionally, we identify emerging trends in contemporary literature that resonate with these interdisciplinary concerns, suggesting a fertile ground for future research and collaboration.

Key Words: Human-Computer Interaction, Becoming-Woman, Deleuze, Ecofeminism, Neural Machine Translation, Interactive Machine Translation.

I. INTRODUCTION

"Becoming" is central to Deleuze and Guattari's thought, especially in their work "A Thousand Plateaus." It represents a movement or process not about achieving a final state or identity but about constant change and flow [1]. It challenges the conventional understanding of identity as fixed and stable. "Becoming" is always in the middle, suggesting it is always in process and never arriving at an end. It resists definitions and is characterized by its dynamism. "becoming-woman" does not mean becoming a woman in the literal, biological sense. Instead, for Deleuze and Guattari, "becoming-woman" is the primary form of becoming, from which other becomings flow. It represents a movement away from majoritarian or standardized identities and towards a space of potential and transformation [2]. "Becoming-woman" is foundational because women in patriarchal structures are often positioned as the 'Other,' outside of the central norm. By initiating the process of becoming "becoming-woman," they emphasize the importance of moving away from established norms and dominant identities.

The concept challenges and disrupts patriarchal hierarchies. By proposing "becoming-woman" as a universal process, not just for women but for men as well, Deleuze and Guattari are suggesting a kind of deterritorialization of identity. In other words, they advocate for dismantling rigid identities and embracing fluid, dynamic processes of becoming, not about imitation but about creating new modes of existence and ways of being in the world [3]. "Becoming-woman" serves as a critique of an escape route from rigid binary distinctions. While "becoming-woman" is gendered in its terminology, its implications extend beyond gender. It is not limited to a gender transformation. Instead, it is a call to think beyond fixed categories and engage in a transform-

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Corresponding Author (*): Wanjin Dong, +86-13838981597, donglele@chungbuk.ac.kr
[1]Department of Clinical Medicine, Nanyang Medical College, Nanyang, China, donglele@chungbuk.ac.kr
[2]College of Humanities, Chungbuk National University, Chungbuk, Korea, pearlpoet@chungbuk.ac.kr
[3]Department of Electronics and Computer Science, Koszalin University of Technology, Koszalin, Poland, adam.slowik@tu.koszalin.pl
[4]Department of Network, Peng Cheng Laboratory, Shenzhen, China, lvjh@pcl.ac.cn

ative transformation for everyone, irrespective of gender. It embodies resistance to any fixed identity and opens up spaces of potentiality and creation. Deleuze and Guattari's philosophical narrative, "becoming-woman," plays a vital role in deconstructing fixed identities, challenging established norms, and proposing a fluid, dynamic understanding of existence [4]. It is a starting point for other becomings and symbolizes a move towards a more inclusive, transformative conception of being.

Ecofeminism is a theoretical and activist standpoint that unites environmental concerns with feminist critique of patriarchy. It is a movement and philosophy that sees a connection between the exploitation and degradation of the natural world and the subordination and oppression of women [5]. The term "ecofeminism" was reportedly first coined by Françoise d'Eaubonne in 1974. The movement gained traction in the 1980s as environmental and feminist activists began seeing the connections between their respective causes. Over the decades, it has expanded to include various strains, encompassing spiritual and secular perspectives and merging insights from ecology, feminism, and social justice. The recognition that patriarchal structures are closely linked to ecological degradation. This is because patriarchy often values domination and control of both nature and women.

Ecofeminists argue that the same patriarchal mindset that oppresses women is responsible for the degradation of the environment. In a patriarchal society, nature and women are often considered resources to be dominated, used, and controlled. Patriarchy often thrives on binaries: male/female, culture/nature, and mind/body [6]. Such dualisms place men, culture, and the mind as superior, while women, nature, and the body are devalued. Ecofeminism challenges these binaries, arguing that they contribute to the hierarchies that result in exploitation. Capitalism and patriarchy often intersect, leading to systems that prioritize profit over ecological and human well-being. The commodification of nature and women's bodies in capitalist patriarchal societies is a significant concern for ecofeminists. Ecofeminists critique the patriarchal underpinnings of mainstream science and its claim to objectivity. They argue that patriarchal science often disregards indigenous, local, and feminine forms of knowledge and instead promotes knowledge that reinforces control over nature. Many ecofeminists delve into spiritual and cultural critiques, arguing that patriarchal religions and cultural norms further the divide between humans and nature by positioning nature as fallen, chaotic, or in need of control. Essentially, ecofeminism provides a unique lens through which to view environmental and feminist issues, highlighting the deep interconnections between nature's degradation and women's oppression in patriarchal societies.

Human-computer interaction (HCI) and artificial intelligence (AI) are integral components of the contemporary digital landscape, with profound implications on how society functions, communicates, and evolves. HCI is an interdisciplinary field that studies technological tools' design, use, and implications, focusing on the interfaces between people and computers [7]. HCI ensures that systems are intuitive, efficient, and user-friendly, enhancing user experience. From smartphones to ATMs to more complex systems like airplane cockpits, HCI principles shape the interactions with technology. HCI research promotes the creation of technology that is accessible to individuals with disabilities, ensuring that digital resources are inclusive. As technology advances, HCI adapts to new interfaces like virtual reality (VR), augmented reality (AR), and wearables.

While AI is the simulation of human intelligence in machines, enabling them to perform tasks that typically require human intelligence, such as visual perception, speech recognition, and decision-making. HCI principles guide the design of AI systems to ensure they meet the needs and preferences of end-users [8]. No matter how advanced, an AI system is only as good as its usability for the intended audience. Both fields intersect in discussions about the ethical implications of AI, especially in ensuring AI systems are transparent, fair, and free from biases. HCI helps in designing interfaces that can explain AI decisions to users. HCI studies how humans and AI can work together effectively, as seen in collaborative robotics, where humans and robots work side-by-side. In conclusion, HCI and AI are reshaping contemporary society at various levels, from everyday personal interactions to macro-level industrial shifts. Their combined influence underscores the importance of designing advanced and human-centric technologies. The core contribution lies in using Deleuzian and ecofeminist concepts as philosophical anchors to evaluate AI advancements in HCI, specifically for literature analysis and translation. Meanwhile, ecofeminism provides an ethical grounding to make AI more inclusive and sustainable. The proposed translation method demonstrates this integration, facilitating access to literary works on "becoming-woman" and ecofeminism across languages.

The rest of this paper is structured as follows. Section 2 integrates the perspectives on becoming, nature, and machine across disciplines. Literary analysis is then used to draw out the connections in Section 3. The interactive neural machine translation methodology and experiments are presented in Section 4. Section 5 gives the discussion and conclusions of the paper.

II. ECOFEMINISM AND HCI: NATURE, GENDER, AND THE MACHINE

2.1. Deleuzian Becoming Intersects with Machines and AI

In the swirling vortex of the digital age, the very essence

of "becoming"—a Deleuzian concept that implies fluid identity and continual transformation—takes on new resonances. When one navigates the terrain of AI and machines, the philosophy of Gilles Deleuze offers a unique lens through which we can understand our shifting selves about these non-human entities [9]. Deleuze's philosophy upends conventional conceptions of identity, advocating instead for a state of constant flux and movement. In the digital landscape, this seems ever more pertinent. Humans no longer exist in isolation or a mere dyadic relationship with machines. Instead, the boundary between the human and the machine is increasingly porous.

AI, as an embodiment of the machine's capability to 'think,' 'learn,' and 'adapt,' challenges our anthropocentric worldview. What makes us distinct if AI can simulate human-like thought processes and even emotions? Deleuze's idea of "becoming-woman," which underscores a shift away from rigid, majoritarian identities, can be transposed to a "becoming-machine." This is not about humans transforming into machines or vice versa. Instead, it is about acknowledging the influence and interrelation between the two and understanding that our identity is co-constructed with technology. This "becoming" with AI is not just theoretical. It is experiential. Consider, for instance, how algorithms shape our choices, from the music we listen to to the news we consume to even our romantic partners. We adapt in response to the machine, just as it adapts to us. In a sense, we are in a state of mutual becoming. Additionally, as digital footprints grow, AI systems create virtual avatars or profiles of users, which might act, think, or make choices like us, even when offline. These avatars might be seen as our digital 'doppelgangers'—extensions of ourselves in the digital realm, yet separate entities [10]. They underscore the Deleuzian idea of the multiplicity of self, with identity not fixed but dispersed and varied.

However, the interaction with AI also surfaces potential pitfalls. The risk of a deterministic digital ecosystem, where our choices are so heavily influenced by algorithms that free will becomes constrained, looms large. The essence of "becoming," which implies potentiality and freedom, might be at stake if our digital surroundings become too prescriptive. Deleuze's philosophy is inherently optimistic, viewing "becoming" as a means to escape from restrictive molds and oppressive structures [11]. It is a call to redefine and reinvent oneself continuously. In our relationship with machines, this can be a reminder: while we may be in a mutual process of becoming with AI, we must also actively shape that process, ensuring it leads to expansion, not constriction.

In the age of the machine, the idea of "becoming" does not diminish; it intensifies. As we chart the unknown territories of a world where humans and machines are inextricably linked, Deleuze offers not a map but a compass—guiding us towards a future where identity is fluid, where the boundaries between human and machine blur, but where the potential for transformation remains infinite.

2.2. The "Self" in HCI – How Evolve or "Become" through Interaction with Technology

The exploration of the "self" in HCI weaves a narrative where technology and humanity are not merely in interaction but in constant dialogue. This dialogue shapes, shifts, and somehow redefines what it means to be human in a technologically-driven age. It is not just that we use technology, but that technology, in turn, influences how we perceive ourselves and our position in the world. The digital interfaces we interact with serve as mirrors, reflecting not a static image but a dynamic, evolving self-portrait. Social media platforms, for instance, invite us to curate versions of our lives to present an "ideal self." This presentation though often critiqued as inauthentic, impacts our self-perception. The constant act of curating, filtering, and editing pushes us to introspect, evaluate, and, in many cases, evolve.

VR and AR technologies take this further. We can adopt avatars, reinvent our physicality, and explore myriad identities in virtual spaces. It allows users to "try on" different selves, to walk in another's shoes, fostering empathy and expanding the scope of personal experience [12-13]. Personal AI assistants adapt to our habits and preferences and are extensions of our cognitive selves. They remember, learn, and anticipate, much like how a part of brain would. The cognitive processes are externalized with them, raising questions about where the self ends and the machine begins. Furthermore, technology also mediates our memory. With digital tools, our past can be revisited with a click. Photos, messages, and videos serve as digital memories, sometimes more vivid than our recollections. Thus, the digital landscape becomes a tapestry of our history, augmenting and sometimes even altering our memories.

Feedback loops in technology, particularly in fitness or health applications, also influence the evolution of our physical self. We gain insights into our physiological being by tracking our steps, heart rate, or sleep patterns. This data can motivate change, leading to a healthier lifestyle or better habits. However, it is essential to recognize that this technological evolution has its pitfalls. The "self" can become fragmented, dispersed across multiple platforms, each demanding a particular version of us, leading to dissonance and anxiety. There is also the challenge of excessive reliance on technology, where the mediated "self" becomes more real or valued than the lived experience. In this dance between the digital and the human, HCI plays the role of choreographer. It is through effective and empathetic design

that the user's experience is made meaningful [14-15]. As technology continues to weave itself into the fabric of daily life, the "self" in HCI emerges not as a fixed entity but as a dynamic, evolving presence, perpetually "becoming" through its dance with the digital.

2.3. The Parallels between the Degradation of Nature and the often Overlooked Ethical Implications in HCI

In a world where digital innovations accelerate and nature faces unprecedented threats, it is tempting to see technology and ecology as opposites. However, a deeper analysis, mainly through the lens of ecofeminism, reveals that they are intrinsically linked, especially in the realm of HCI. Ecofeminism posits that the degradation of nature is intertwined with the oppression of women, rooted in a patriarchal system that often values domination over harmony [16]. The same system historically sought to control and subjugate women also seeks to control and exploit nature. The logic of domination extends to how we approach machines and, by extension, how we design and interact with technology.

At its core, HCI is about the relationship between humans and computers. It is about interface, interaction, and, ultimately, integration. However, just as ecofeminism identifies patterns of subjugation in societal structures, we can also discern these patterns in digital structures. Machines are often designed for efficiency and utility, stripping away the "organic" or "natural" aspects of interaction. The traditional design often sees the user and the machine in a hierarchical structure: the human commands and the machine obeys. This mirrors the age-old dominion of man over nature, a perspective that ecofeminism critiques. Instead of viewing technology as merely a tool for human ends, we might consider more symbiotic relationships, where technology and humanity co-evolve and co-adapt. Just as ecofeminism promotes a more holistic understanding of the environment, seeing it not as separate but as an integral part of human existence, HCI can evolve to view technology not as external but as an extension of the human experience [17-18]. This shift is not just philosophical but has practical implications. For instance, designing with nature in mind could lead to more sustainable tech practices, from biodegradable hardware components to energy-efficient software applications.

Gender plays a pivotal role in this discourse. The feminine has often been associated with nature, emotion, and intuition, qualities that are sometimes overlooked in the digital realm. However, what if HCI were to embrace these qualities? It could lead to interfaces that feel more organic, algorithms that understand human emotion, and digital environments that change and grow, much like natural ones. Moreover, as AI becomes more advanced, ethical questions arise about machine rights and machine "suffering." If machines gain consciousness or sentience, the dominion of man over machine, much like the dominion over nature and women, becomes an ethical quandary. In this intricate dance of nature, gender, and the machine, ecofeminism offers a fresh perspective, reminding HCI practitioners of their designs' ethical and holistic considerations. By aligning technological advancements with ecological and feminist principles, we can craft a digital future that is innovative, harmonious, and just.

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2.4. Biases and Inclusiveness

The dawn of the AI era has brought unparalleled advancements, revolutionizing sectors from healthcare to entertainment. However, beneath this shimmering surface lies an underlying issue: AI's inherent biases, mainly related to gender [19-20]. As AI systems are primarily designed and trained by humans, they inevitably inherit our conscious and unconscious prejudices. An ecofeminist perspective challenges these biases, advocating for an inclusive and holistic approach to AI. Algorithms, though seemingly impartial, often harbor gendered biases. Facial recognition software, for example, has been found to misidentify women, especially those with darker skin tones, at higher rates than men. Similarly, job screening algorithms can favor male candidates over female ones based on biased training data. These are not mere glitches but symptomatic of a deeper problem: the systematic sidelining of diverse voices in the development of AI.

Ecofeminism emphasizes the interconnections between the oppression of women and the degradation of nature, positing that both stem from a patriarchal system of domination. Applied to AI, this suggests that the biases in algorithms reflect a broader societal issue, where technology perpetuates existing power structures rather than challeng-

ing them. However, the marriage of ecofeminist principles and AI offers a path forward. By acknowledging and challenging gender biases, we can begin deconstructing them within our digital systems. An inclusive approach means diversifying the teams that design and develop AI, ensuring that multiple perspectives are considered and that algorithms benefit from a richer, more varied training dataset.

Beyond rectifying gender biases, an ecofeminist approach to AI also promotes harmony with nature [21]. Instead of designing AI systems that further strain our planet's resources, the focus could shift toward sustainability, manifesting in energy-efficient algorithms, ethical sourcing of hardware materials, or even AI solutions that tackle environmental issues directly. By intertwining the threads of gender equality and ecological awareness, AI's potential is not just in its computational prowess but in its capacity to reshape societal norms. It can champion a world where technology reflects the diverse tapestry of its users and where machines work in tandem with, not against, the natural world. To harness AI's transformative power, it is crucial to look beyond mere technicalities and delve into its design and application's ethical and philosophical dimensions. An ecofeminist lens emphasizing inclusivity and ecological harmony offers a compelling blueprint for an AI landscape that's smart and wise.

2.5. Contemporary Literature: Echoes of Deleuzian and Ecofeminist Thought

In the heart of contemporary literature lies a vibrant tapestry woven with themes of becoming, nature, gender, and technology. While reflective of the present zeitgeist, these threads carry echoes of earlier philosophical discourses, particularly the Deleuzian concept of "becoming" and the interconnections highlighted by ecofeminism. D.H. Lawrence's writings, with their exploration of human nature, industrialization, and gender dynamics, serve as a rich foundational bedrock for this literary examination. Modern literary protagonists often grapple with the fluidity of identity, mirroring Deleuze's "becoming-woman" concept, which is not merely about gender transition but represents a broader movement towards decentralization, breaking away from fixed identities and societal norms. Books like Jeanette Winterson's "The Passion" [22] or Ali Smith's "How to Be Both" [23] resonate with this fluidity, presenting characters that defy categorization and traverse mutable landscapes of self. Ecofeminism's dual critique of patriarchal oppression and environmental degradation finds a voice in many contemporary novels. Margaret Atwood's "The Handmaid's Tale" and its sequels delve deep into a dystopian society where women and nature are subjugated [24]. Meanwhile, Barbara Kingsolver's "Prodigal Summer" weaves interconnected stories of women, wilderness, and their intricate relationships, emphasizing the mutual respect and understanding necessary for personal and ecological harmony [25].

The intertwining of gender and nature in Lawrence's "The Rainbow" finds parallels in novels like "The History of Bees" by Maja Lunde [26]. Lunde's narrative spans time, capturing the profound relationships between parents and children and humans and nature, echoing the overarching theme of interconnectedness prominent in ecofeminist thought. Technology, an ever-pervading motif in contemporary literature, is also pivotal. From the virtual landscapes in Neal Stephenson's "Snow Crash" [27] to the AI-driven societies in Ian McEwan's "Machines Like Me," [28] modern narratives grapple with humanity's evolving relationship with technology. These works explore how technology shapes identity, challenges traditional gender roles, and often poses existential questions about nature and authenticity in an increasingly digitized world. However, beyond these thematic echoes, the narrative structures often reflect Deleuzian and ecofeminist influences. Non-linear timelines, fragmented narratives, and shifting perspectives, as seen in works like David Mitchell's "Cloud Atlas," mirror the non-binary, interconnected worldview these philosophies advocate [29].

Considering the salient linkages to Deleuzian and ecofeminist thought: (i) Characters with fluid identities align with Deleuze's deterritorialization. (ii) Nonlinear narratives mirror interconnected ecofeminist perspectives. (iii) Technology reshaping human relationships reflects risks of environmental alienation. (iv) Intertextuality embodies Deleuze's creative repetition. (v) Reimagined archetypes challenge dualisms. Contemporary literature, in its myriad forms, reflects the evolving societal consciousness, drawing heavily from philosophical wellsprings like Deleuze and ecofeminism. As readers delve into these narratives, they engage with stories and profound philosophical inquiries that have resonated through the ages, from Lawrence's era to our own.

III. TOWARDS A NEW AI PARADIGM: THE HARMONIZATION OF BECOMING, NATURE, AND MACHINE

3.1. Narratives of AI: Storytelling in an Age of Digital Transformation

The rapid ascent of AI is more than just a technological evolution; it is a profound cultural shift, reshaping the stories we tell and how we understand our place in the digital cosmos. As AI infiltrates everyday life— powering chatbots, virtual assistants, recommendation systems, and more—its narratives become a battleground where age-old

gendered and environmental ideologies are entrenched or subverted. AI narratives are often crafted through human-centric lenses, drawing from deep wells of cultural, historical, and social contexts. The way we personify these technologies frequently defaults to existing societal archetypes. Consider, for instance, the proliferation of female-voiced virtual assistants like Siri, Alexa, or Cortana. The gender choice of these interfaces is not neutral; it reflects and potentially amplifies ingrained gender dynamics, positioning AI as servile, accommodating, or submissive—traits that have historically been imposed upon women. Additionally, the anthropomorphic personas we craft for chatbots or virtual agents often mirror human hierarchies and biases. These digital entities, predominantly coded and designed by a non-diverse group, risk perpetuating stereotypes, whether it is a demure female chatbot or an assertive male-oriented gaming AI.

From an environmental perspective, the digital is often falsely presumed to be "clean" or intangible, disconnected from the natural world. However, vast server farms, resource-intensive manufacturing processes for devices, and the electronic waste generated all leave indelible marks on the environment. The narratives of AI's limitless possibilities sometimes overshadow these ecological footprints, leading to a digital utopianism that neglects the planet's genuine physical constraints. However, this is not a one-sided tale of perpetuation. AI also offers opportunities to challenge, reimagine, and redefine traditional narratives. Developers and designers are now more conscious than ever, striving to create inclusive AI systems that eschew bias. Efforts are underway to depersonalize or de-gender virtual assistants, making them more neutral and less reflective of gendered hierarchies. Simultaneously, eco-conscious AI solutions are emerging, optimizing energy use, reducing waste, or directly addressing environmental challenges.

Literature, film, and art further contribute to this reimagining, portraying AI entities that defy gender norms, challenge human hubris, or emphasize symbiosis with the natural world [30]. In this digital transformation age, AI's narratives serve as a mirror, revealing the best and worst of humanity's hopes, fears, biases, and aspirations. By critically engaging with these stories, society can shape AI that reflects a more equitable, just, and sustainable world and actively drives us towards it.

3.2. A New Direction for AI Development Integrating Deleuzian Becoming and Ecofeminist Values

Amid the AI renaissance, with machines crunching data at unfathomable speeds and algorithms predicting intricate human behaviors, a pressing need emerges to rethink the philosophical underpinnings of AI development. Rooted in the Deleuzian concept of 'becoming' and the profound interconnections underscored by ecofeminism, this essay proposes a visionary shift in AI's trajectory, aligning it more closely with organic processes, inherent interconnectedness, and a respect for both human and non-human entities. At its core, Deleuze's idea of 'becoming' opposes static identities, championing fluidity, multiplicity, and transformation. Translated into the AI realm, 'becoming' challenges the binary, deterministic nature of traditional algorithms. Instead of creating AI systems that merely simulate static human behaviors or mindsets, the focus should shift toward developing adaptable, mutable, and continuously evolving systems. Such an AI would not just solve problems; it would 'become' through the process, adapting and evolving in response to ever-changing inputs.

Ecofeminism critiques the dualistic logic that separates humans from nature and men from women [31]. By integrating ecofeminist values, AI can be designed to recognize and honor these inherent connections, not as mere data points but as essential truths of existence, which means developing algorithms that are attuned to the delicate balance of ecosystems, prioritizing sustainability, and understanding that every output has ripple effects in the interconnected web of existence. Additionally, moving away from the patriarchal underpinnings often dominating tech, an ecofeminist approach would prioritize collaboration, inclusivity, and holistic well-being over dominance and competition. AI systems would be designed to nurture rather than exploit, to connect rather than isolate and to sustain rather than drain.

The new AI paradigm would be a harmonious blend of organic 'becoming' and machine precision. AI systems would be decentralized, drawing inspiration from natural ecosystems where every entity plays a vital role, no matter how small. They would function more like neural networks, not just in their technical architecture but in their essence, mirroring the human brain's adaptability and the natural world's resilience. Imagine AI that evolves with each interaction in terms of efficiency, understanding, and empathy. Virtual assistants not only streamline tasks but adapt to the emotional states of their users, prioritizing well-being over productivity. Conservation algorithms do not just analyze deforestation rates but understand the cultural and spiritual significance of forests for indigenous communities. Therefore, the overall architecture is shown in Fig.1.

IV. METHODOLOGY

4.1. Machine Mediated Becoming

Integrating interactive machine translation (IMT) into the domain of HCI offers a promising avenue to enrich the interdisciplinary dialogue around Deleuze's "becoming-

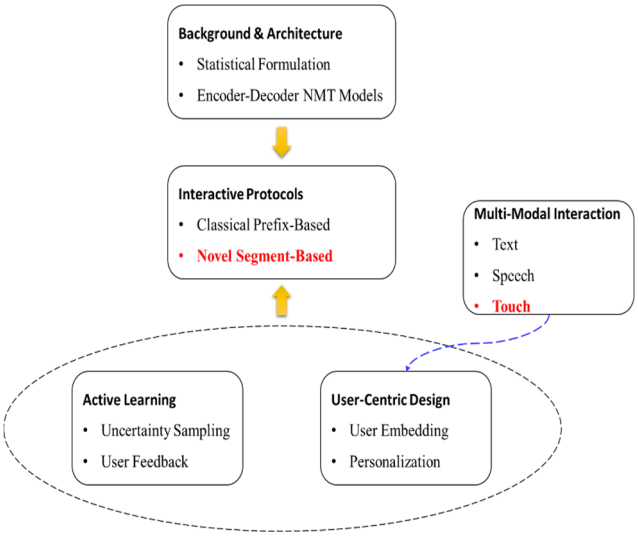

Fig. 1. Overall architecture.

woman," ecofeminism, and contemporary literature in the context of AI advancements. IMT is transforming our communication landscape. At its core, IMT is not just about translating words from one language to another but facilitating genuine human-to-human connections across linguistic and cultural divides (Domingo et al., 2017; Ye & Guo, 2022 [32-33]). This bridging capability becomes a powerful tool when considering the philosophical and socio-cultural implications of Deleuze's "becoming-woman" and the tenets of ecofeminism in contemporary AI-driven literature. The beauty of "becoming-woman" is its celebration of fluidity, multiplicity, and transformation. IMT echoes this fluidity by allowing for real-time, bidirectional feedback between humans and machines. It is a dance of mutual adaptation, where neither human nor machine holds a fixed identity, but both are in a constant state of 'becoming' through their interaction.

By leveraging IMT in exploring literature that touches upon "becoming-woman", readers worldwide, irrespective of their linguistic background, can delve deep into the nuances of such texts. They can engage in discussions, share interpretations, and collaboratively contribute to a richer understanding of the material. This dynamic interaction, where the machine aids in breaking down linguistic barriers and the human enriches the discourse with cultural and personal insights, mirrors Deleuze's emphasis on continuous evolution and change.

Ecofeminism, focusing on interconnectedness and its critique of patriarchal structures, finds a potent ally in IMT. Through IMT, literature that resonates with ecofeminist values becomes globally accessible. This widespread accessibility fosters a collective awareness of the intricate ties between gender, nature, and technology. It encourages global dialogues, collaborative problem-solving, and the sharing of diverse strategies to address the dual challenges of gender inequality and environmental degradation.

4.2. Interactive Neural Machine Translation

This subsection describes the proposed approach for integrating neural machine translation (NMT) models into IMT protocols. We first provide background on the statistical formulation of machine translation that serves as the basis for our techniques [34]. We then explain the architecture and training of encoder-decoder NMT models. Next, we present the classical prefix-based IMT approach and propose a novel segment-based interactive protocol. We also provide algorithms for the training procedures and interactive decoding. Finally, we explain how the NMT search process must be constrained to account for user feedback under the interactive paradigms.

4.2.1. Preliminary

We formulate machine translation (MT) in the statistical framework widely used in [35]. Given a source language sentence $x = (x_1, \dots, x_J)$ of length J, the goal is to find the target translation $y = (y_1, \dots, y_I)$ of length I that maximizes the conditional probability:

$$\hat{y}1^I = \operatorname{argmax} I, y_1^I \Pr(y_1^I | x_1^J). \quad (1)$$

Using the chain rule, we can decompose this as:

$$\Pr(y_1^I | x_1^J) = \prod_{i=1}^{I} \Pr(y_i | y_1^{i-1}, x_1^J). \quad (2)$$

Therefore, translation can be posed as a sequential word prediction problem, where the probability of each target word y_i is conditioned on the previously generated words y_1^{i-1} and the full source sentence x_1^J.

Early statistical machine translation systems modeled $\Pr(y|x)$ using word-based alignment models. Phrase-based translation later became dominant [36], utilizing bilingual phrases as translation units. More recently, neural network-based approaches have achieved state-of-the-art performance by directly modeling $\Pr(y|x)$. We focus on NMT in this work.

4.2.2. Neural Machine Translation

NMT aims to directly model $\Pr(y|x)$ using a single, large neural network. Most architectures follow an encoder-decoder paradigm. The encoder reads and encodes the source sentence into a distributed representation. The decoder then generates the target translation from the encoded representation.

The source sentence $x = (x_1, \dots, x_J)$ is first converted into a sequence of word embeddings $e_x = (e_{x_1}, \dots, e_{x_J})$

where $e_{x_j} \in \mathbb{R}^m$. An embedding matrix $\boldsymbol{E} \in \mathbb{R}^{|V_x| \times m}$ maps each source word to its m-dimensional embedding vector, where V_x is the source vocabulary.

We utilize pre-trained embeddings, as they have been shown to improve performance. The embedding matrix $\boldsymbol{E}$ is initialized with embeddings pre-trained using Word2Vec on large monolingual corpora. The matrix can be further tuned during NMT training.

The sequence of embeddings e_x is then processed by a multi-layer bidirectional long short-term memory (LSTM) network. The LSTM computes a sequence of annotation vectors $h = (h_1, \ldots, h_J)$ capturing contextual dependencies from both directions:

$$\begin{aligned} h_j &= \left[\overrightarrow{\mathrm{LSTM}}\left(e_{x_j}\right); \overleftarrow{\mathrm{LSTM}}\left(e_{x_j}\right)\right] \\ &= \left[\mathrm{LSTM}\left(e_{x_j}, \vec{h}_j - 1\right); \mathrm{LSTM}\left(e_{x_j}, \overleftarrow{h}_{j+1}\right)\right], \end{aligned} \tag{3}$$

where $\overrightarrow{\mathrm{LSTM}}$ and $\overleftarrow{\mathrm{LSTM}}$ denote the forward and backward LSTMs respectively.

Using a deep LSTM stack allows the model to compose higher-level representations of the source sentence. Depth has been shown to improve encoding quality.

To focus on relevant parts of the source representation h, an attention mechanism is used. At each decoding timestep i, a context vector c_i is computed as a weighted sum of the annotations h:

$$c_i = \sum_{j=1}^{J} a_{ij} h_j. \tag{4}$$

The weight a_{ij} determines the relevance of input around position j for generating the ith target word. These are computed by a feedforward network f_{att} as:

$$a_{ij} = f_{att}(s_{i-1}, h_j), \tag{5}$$

where s_{i-1} is the recurrent neural network hidden state from the previous timestep. Different variants of the attention function f_{att} have been proposed, such as the additive and multiplicative forms.

The decoder generates the target translation $y = (y_1, \ldots, y_I)$ autoregressively, predicting each word conditioned on the previously generated words and the source context.

Specifically, each word y_i is predicted based on:

· The embedding $e_{y_{i-1}}$ of previous word y_{i-1}

· The previous decoder state s_{i-1}

· The source context vector c_i

These are fed into a multi-layer LSTM network which computes the next state s_i. The probability distribution over possible outputs is then:

$$p(y_i | xy_{<i}, x) = g\left(e_{y_{i-1}}, s_{i-1}, c_i\right), \tag{6}$$

where g is a non-linear function based on the LSTM output. g projects to the target vocabulary size, applying a softmax to obtain normalized probabilities.

The full architecture combines the above components into a single neural network. By training end-to-end on parallel text, the model learns encodings and decoding strategies suited for the translation task.

4.2.3. Training Procedure

The encoder and decoder networks contain trainable parameters Θ. These are optimized to maximize the conditional log-likelihood of training pairs $(x^{(s)}, y^{(s)})$ from a parallel corpus:

$$\widehat{\Theta} = \underset{\Theta}{\operatorname{argmax}} \sum_{i=1}^{S} \sum_{i=1}^{I_s} \log p\left(y^{(s)} i | y^{(s)} < i, x^{(s)}; \Theta\right), \tag{7}$$

where S is the number of sentences, and I_s is the length of target sentence s.

We optimize Eq. (7) using minibatch stochastic gradient descent. The gradient is computed via backpropagation through the unrolled network computational graph.

We utilize minibatch SGD for efficiency, drawing random subsets of training pairs to approximate the full gradient. The learning rate η controls the gradient step size. Various schedules can be employed, such as decaying η over time.

The parameters θ include the embeddings, LSTM weights and attention layers. Batch normalization is applied to stabilize training. We also use dropout as a regularization method.

4.2.4. Decoding

To translate a new source sentence x, we seek the target $\hat{y}$ that maximizes the conditional probability:

$$\hat{y} = \underset{y}{\operatorname{argmax}} \Pr(y|x). \tag{8}$$

Algorithm 1. NMT training procedure

```
Begin
Input: parallel corpus D = (x^(s), y^(s)), model p_θ
initialize model parameters θ
repeat:
sample minibatch B = (x_b, y_b) from D
for (x_b, y_b) in B do
compute loss L(θ; x_b, y_b) // Eq. (7)
end-for
until convergence
End
```

Algorithm 2. Beam search decoding

```
Begin
  Input: source x, model p_θ, beam size K
  initialize: H_0 = ⟨SOS⟩, t = 1
  repeat:
    H_t = ∅
    for ⟨y_{1:i−1}⟩ in H_{t−1} do
      for y_i in top K vocabulary do
        p = p_θ(y_i|y_{1:i−1}, x)
        Add ⟨y_{1:i}⟩ to H_t with score p
      end-for
    end-for
    keep top K hypotheses in H_t
    until ⟨y_{1:I}⟩ in H_t, y_I = EOS
  Output: best ⟨ŷ⟩ from H_t
End
```

Since enumerating all possible y is intractable, we use beam search to approximately find the most likely translation. Algorithm 2 describes the procedure.

We expand every partial hypothesis in the beam at each timestep by considering all possible next words. We then select the top K hypotheses based on their scores. Once the end token is generated, we choose the highest-scoring complete hypothesis as the final output.

Larger beam sizes improve search accuracy at the cost of speed. Typical values range from 5 to 20.

The above describes open-ended decoding to translate generic input text. Next we explain how to adapt the search process for interactive translation.

4.2.5. Proposed Method

We introduce methods for integrating NMT models into IMT protocols. In this interactive approach, the system suggests potential translations. Users can correct these suggestions through iterative feedback, enabling quicker convergence to accurate outputs.

The widely adopted approach to interactive MT is the prefix-based protocol. Here, the user always provides feedback by correcting the leftmost erroneous word in the system hypothesis.

Specifically, suppose the system generates an initial translation $y_{1:I}$. The user identifies the first incorrect word, say at position t, and provides the corrected word $\hat{y}_t$ to replace y_t.

This validates the prefix $y_{1:t-1}$ while correcting position t. The feedback signal is thus $f = (\hat{y}_{1:t})$.

Given f, the system must produce an updated translation respecting this constraint. Mathematically, we seek:

$$\hat{y}_{t+1:I} = \text{argmax}\, I, y_1^I y_{t+1:I} \Pr(y_{1:t-1}, \hat{y}_t, y_{t-1:I}|x). \quad (9)$$

That is, we search for the optimal suffix $y_{t+1:I}$ given the validated prefix $\hat{y}_{1:t}$.

Algorithm 3. Prefix-based interactive decoding

```
Begin
  Input: source x, feedback f = (ŷ_{1:t})
  initialize model parameters θ
  H_0 = ⟨ŷ_{1:t}⟩ // initialize with f
  use beam search (Algorithm 2)
  Output: best hypothesis with prefix f
End
```

To generate this using the NMT model, we simply restrict beam search to only hypotheses beginning with $\hat{y}_{1:t}$. The resulting translation after selecting the highest scoring suffix is then presented to the user.

The interaction cycle continues, validating longer prefixes each iteration, until the user accepts the final output.

Algorithm 3 summarizes the prefix-based interactive decoding procedure. The key difference from generic beam search is initializing the beam with the validated prefix f from the user feedback.

While effective, the prefix-based approach forces the user to always correct from left to right. The proposed segment-based interaction provides more flexibility. To allow finer-grained user guidance, we introduce a segment-based interaction protocol. Here, the user can validate any contiguous segments of words from the hypothesis assumed to be correct.

For a system hypothesis $y_{1:I}$, a validated segment is defined as $f = (y_i, \ldots, y_{i'})$ for some $1 \le i \le i' \le I$. The user can select multiple such segments from $y_{1:I}$. Additionally, the user provides a single word correction $\hat{y}_t$ at some position t, same as in prefix-based interaction. The feedback signal is then $f_{1:N} = (f_1, \ldots, f_N)$, where each f_n is a validated segment, and $\hat{y}_t$ is included as a 1-word segment correction. Given this, the system must produce an updated translation y' that incorporates the validated segments and correction. Let the gaps between validated segments be $g_{1:N} = (g_1, \ldots, g_N)$. We seek to fill these gaps with new predictions as follows:

$$\hat{g}_{1:N} = \text{argmax}\, g_{1:N} \Pr(f_1, g_1, \ldots, f_N, g_N|x). \quad (10)$$

Namely, we search for the non-validated segments that together with the validated ones maximize the probability of the full hypothesis. However, the lengths of each g_N are unknown during decoding. We address this using the following strategy:

For each gap between validated segments:

- Decode M hypotheses filling the gap with 0 to M words
- Select the length giving the highest average probability
- Generate g_n by restricting decoding to this length

Algorithm 4. Segment-based interactive decoding

```
Begin
  Input: source x, feedback f_{1:N}
  y' = ∅ // output hypothesis
  for n = 1 to n do
    if f_n is not ŷ_t
      append f_n to y' // add validated segment
    end-if
    L = argmax 0 ≤ l ≤ M (1/(l+1)) Pr(g_n | f_{1:n-1}, y', x) // pre dict gap length
    generate g_n by restricting decoding to L words
    append g_n to y'
  end-for
  Output: constructed hypothesis y'
End
```

The motivation is to let the model decide the optimal length of each non-validated segment. M controls the maximum gap length. The final output translation is constructed by interleaving the validated and predicted segments. Algorithm 4 provides the full procedure.

A core challenge in interactive MT is that user feedback is only available at inference time and never during training, which can result in a mismatch between the static training objective and the interactive inference procedure. We propose a novel training regimen incorporating simulated user feedback to overcome this. The key idea is to simulate user interactions on the training data and use these to steer the model parameters towards better-handling user guidance.

The training process is as follows. For each training sentence pair (x, y^*):

Step 1. Generate an initial hypothesis $\hat{y}^{(0)}$.

Step 2. Simulate user validating segments of $\hat{y}^{(0)}$ matching $\hat{y}$.

Step 3. Generate updated hypothesis $\hat{y}^{(1)}$ with simulated feedback.

Step 4. Compute loss comparing $\hat{y}^{(1)}$ to $\hat{y}$.

Step 5. Update model parameters using loss and gradient descent.

By simulating the interactive inference process during training, the model is trained to integrate user signals. This results in improved handling of real user interactions during inference. The segment selection and decoding strategies mirror those at test time. However, the "user" has direct access to the reference $\hat{y}$. Segments matching $\hat{y}$ are probabilistically sampled for validation based on model confidence scores. This approach combines the benefits of maximum likelihood training on full sentence pairs, with learning to interactively refine outputs. We find it crucial for achieving good live iteration performance.

To enable the simulator to select valid segments, we require word-level confidence estimates for the NMT outputs. Specifically, we wish to estimate:

$$p_{\text{correct}}(y_i) = \Pr(y_i = y_i^* | x). \tag{11}$$

We implement g as a small feedforward neural network taking as input:

· Word embeddings of $y_{1:I}$

· Encoder states y_j from NMT model

· Decoder state s_i when emitting y_i

· Position encoding of i

This provides strong context when predicting $p_{\text{correct}}(y_i)$. The network g is trained using cross-entropy against the true correctness values. At inference time, the confidence scores allow selecting validated segments that are likely to match the user's intended corrections.

The full training procedure including the confidence model and simulated feedback is summarized in Algorithm 5.

This provides a framework for training NMT models to integrate real-time user feedback signals effectively, as shown in Fig. 2. Experiments demonstrate significant improvements in live iteration performance compared to models trained without simulated interactions.

A practical challenge in interactive MT is the possibility of incorrect user feedback. Users may sometimes validate incorrect segments or provide wrong corrections. The system should be robust to such errors. We employ several techniques to mitigate the impact of improper user feedback:

· Confidence filtering: Segments with low model confidence are not validated, even if selected by the user, avoiding reinforcing uncertain predictions.

· Forgetting factor: When updating model parameters during simulated training, recent iterations are given higher weight than earlier ones, reducing the influence of outdated corrections.

· Error detection: The system detects when a user correc-

Algorithm 5. Interactive NMT (iNMT) training

```
Begin
  Input: corpus D = (x^(s), y^(s)), NMT p_θ, confidence g_φ
  repeat:
    sample (x, y) from D
    ŷ^(0) = Decode(x) // initial translation
    f = SimulateFeedback(ŷ^(0), g_φ)
    ŷ^(1) = Decode(x, f) // with feedback
    update θ, φ using L(ŷ^(1), y*)
  until convergence
End
```

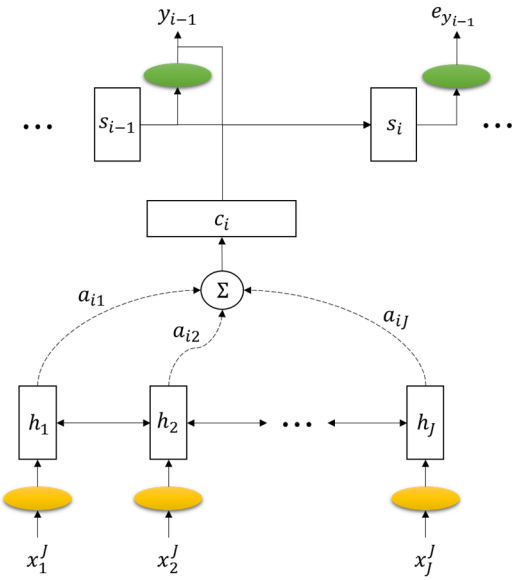

Fig. 2. Architecture for interactive machine translation.

tion results in a lower model probability than the original word. In such cases, the original is kept instead.

- Model averaging: We maintain an exponential moving average of parameters over training steps. This smooths parameter changes to prevent overfitting to incorrect signals.
- With these mechanisms, we find the system able to gracefully handle occasional user errors during interaction. The model steadily improves from the well-intentioned feedback while preventing degradation from improper guidance.

A limitation of conventional MT systems is that they produce generic outputs, unable to adapt to users' preferences. Interactive translation provides an opportunity to learn from user feedback and personalize over time. We explore a simple personalization approach motivated by user modeling in computer vision. The key idea is to condition decoder predictions on an embedding learned for each user:

$$p(y_i|y_{<i}, x, u) = f\left(e_{y_{i-1}}, s_{i-1}, c_i, z_u\right), \tag{12}$$

where $z_u \in \mathbb{R}^d$ is a learned embedding for user u. This vector is appended as input to the decoder at each timestep, allowing customization of outputs.

The user embedding z_u is randomly initialized and optimized on data from interactions with user u. We update z_u at each simulated training iteration to account for the provided feedback.

At inference, the model predicts translations personalized to the particular user based on their interactive history encoded in z_u. Our experiments show improved subjective satisfaction through this technique.

While interactive MT allows users to guide the system, manually providing feedback can still be challenging. We explore combining with active learning to further reduce user effort.

At each iteration, the system must decide between two options: request user feedback on its current hypothesis or autonomously make corrections by searching for the most probable valid segments.

The system only queries the user when uncertain and relies on its predictions in other cases. This approach is a variant of uncertainty sampling used in active learning. To implement this, the system computes the total confidence C on its current hypothesis y:

$$C(y) = \sum_{i=1}^{I} p_{\text{correct}}(y_i). \tag{13}$$

If $C(y)$ falls below a threshold, the system requests feedback from the user. Otherwise, it searches for the highest scoring valid segments to apply as corrections:

$$\hat{y} = \underset{y'}{\text{argmax}}\, C(y') : p_{\text{align}}(y', y) > \delta, \tag{14}$$

where $p_{\text{align}}(y', y)$ measures the similarity between two hypotheses, and δ controls the search space. This active approach maximizes the impact of user feedback when it is needed most.

Finally, we explore extending beyond text-only interaction by incorporating speech and touch input modalities. The user can provide spoken corrections using automatic speech recognition (ASR). To mitigate ASR errors, we integrate confusion network decoding. The N-best recognition hypotheses are compactly represented as a confusion network. Interactive decoding integrates multiple hypotheses:

$$\hat{y} = \underset{y}{\text{argmax}} \sum_{a \in A} \Pr(y|x, a) \Pr(a|x_{\text{audio}}), \tag{15}$$

where A is the space of ASR hypotheses for the spoken correction x_{audio}, marginalizing over uncertainties in the acoustics.

We utilize an electronic pen overlay on the translation display for touch interaction. Users can cross out incorrect words or segments directly and write new words using handwriting input. The corrections are recognized using neural handwriting recognition and integrated into the interactive MT process. We enable more natural user interaction with the translation system by supporting multimodal inputs.

4.3. Experiments

We conduct extensive experiments to evaluate the proposed iNMT method. We first describe the experimental setup, including datasets, baselines, metrics, and implementation details. We then present results analyzing translation quality, human effort, active learning, and multimodal interaction.

4.3.1. Experimental Setup

We utilize standard benchmark datasets for machine translation across various domains and language pairs:

· International conference on spoken language translation (IWSLT) is a renowned scientific workshop in spoken language translation. It is a platform where researchers and scholars from around the globe converge to discuss, share, and innovate in automatic transcription, translation of speeches, and related applications.

· Europarl. The Europarl corpus is a widely-used linguistic resource in machine translation and natural language processing. It is a collection of parallel texts extracted from the proceedings of the European Parliament.
· News Commentary. The News Commentary corpus is a collection of bilingual parallel texts, often utilized in machine translation and natural language processing. It is an essential resource for researchers aiming to develop and refine translation systems, particularly between European languages.
· WMT. The WMT Corpus is associated with the annual workshop on machine translation (WMT), a premier event in the machine translation community. Each year, WMT organizes shared tasks that involve translating texts between various language pairs, and for these tasks, the WMT releases datasets collectively referred to as the WMT corpus.

For interactive experiments, we simulate user feedback on these datasets and collect actual human interaction data by having users post-edit initial system outputs. Table 1 summarizes the dataset statistics. We report results on standard test sets for each corpus.

A few fundamental limitations exist to using automated translation metrics like BLEU for evaluating interactive or human-in-the-loop machine translation systems. BLEU only evaluates n-gram precision and does not account for semantic correctness or fidelity. Human feedback aims to improve meaning and fluency, aspects not captured by BLEU. BLEU relies on comparison to reference translations, which are subjective and may not reflect valid interactive improvements. BLEU assumes consistent human references/judgments, while subjectivity and inter-annotator differences affect interactive systems. Practical challenges make running large-scale live user trials difficult to obtain human interactive translations for evaluation. While BLEU remains useful for system development, more than automated metrics are needed for comprehensively evaluating IMT systems. Human studies assessing qualitative aspects like usability and accuracy perception are essential to complement BLEU's limitations. Hybrid evaluation frameworks can help assess both computational performance and collaborative translation quality. Therefore, we assess both translation quality and human interaction effort using the following automatic metrics:

Table 1. Dataset statistics.

Dataset	Language pair	Training size	Test size
IWSLT	English-German	230k	1k
Europarl	English-French	2.0M	2k
News commentary	English-Czech	300k	1k
WMT	English-Finnish	5.0M	3k

· Bilingual evaluation understudy (BLEU): n-gram precision for MT evaluation
· Translation edit rate (TER): edit distance between hypothesis and reference
· Keystrokes: Number of word corrections by the user
· Mouse clicks: Number of segment selections using the mouse

Additionally, we report results from human studies evaluating the system usability and user experience.

We compare the proposed iNMT method against the following baselines:

· NMT: Non-interactive neural MT
· PBMT [36]: Phrase-based MT with interactive features
· HMMT [37]: Hierarchical MT with interactive decoding

All methods utilize the same training data and base model architecture for a fair comparison. The core difference lies in the interactive decoding algorithms.

The proposed iNMT method is implemented in PyTorch using the following model architecture:

· Two-layer bidirectional LSTM encoder
· Attention mechanism: dot product
· Two-layer LSTM decoder
· Embedding size: 512
· Hidden state size: 1,024

The model is trained using Adam with a learning rate of 2e-4 and batch size 64. We implement custom CUDA ker-

nels to simulate user interactions during training efficiently. The maximum validated segment length M is set to six words. The beam size for decoding is 10. All experiments are conducted on servers with NVIDIA GeForce RTX 3070 GPU.

4.3.2. Results on Translation Quality

We first evaluate translation quality on the test sets. Table 2 compares different systems using the BLEU automated metric.

From Table 2, we observe that the proposed iNMT method achieves the highest BLEU across all datasets, outperforming both non-interactive NMT and prior interactive MT methods and demonstrating the benefits of the proposed method. While HMMT is competitive, showing the value of hierarchical translations for interaction. However, the sequential NMT architecture better integrates user signals. PBMT performs worst overall due to a lack of semantic modeling capabilities.

The integration of a highly effective iNMT method, as evidenced by its performance from Table 2, into the broader landscape of HCI presents a significant opportunity to amplify discussions on Deleuze's "becoming-woman," ecofeminism, and their intersections with AI advancements in contemporary literature. Given the superior performance of iNMT, literature around "becoming-woman" and ecofeminism can be made accessible to a global audience. The ideas rooted in Deleuze's philosophy and ecofeminism can permeate diverse linguistic and cultural contexts by erasing language barriers, fostering global discourse, and enabling more decadent interpretations. The interactive nature of iNMT allows users to provide feedback or corrections in real time. This interactive feedback loop mimics the Deleuzian notion of 'becoming,' as the translation process is not static but evolves dynamically based on human input. This symbiotic relationship between humans and AI underscores the potential for harmonious coexistence. By facilitating translation, it brings to the forefront diverse feminist narratives from different cultures, helping to build a comprehensive, intersectional understanding of ecofeminism, which can lead to a richer tapestry of narratives that honor both the specificity of localized struggles and the universality of feminist and ecological concerns. With the democratization of literature access, there is a potential for a more profound influence of ecofeminist and Deleuzian values on AI ethics. Developers, policymakers, and AI enthusiasts from different linguistic backgrounds can draw inspiration from these works, potentially shaping a more inclusive and respectful tech landscape. Integrating high-performing iNMT systems can lead to more organic, intuitive, and empathetic user interfaces. Drawing inspiration from ecofeminist values, future HCI designs can be centered around interconnectedness, mutual respect, and holistic well-being, where technology is not an external tool but an extension of our organic selves. Given the shared global challenges like climate change, leveraging iNMT to make ecofeminist literature accessible can lead to global collaborations. Communities can share localized strategies, success stories, and cautionary tales, fostering a collective approach to global challenges. Essentially, iNMT is an enabler, a bridge, and a catalyst that can profoundly influence the convergence of Deleuzian thought, ecofeminism, and AI advancements, weaving together the threads of philosophy, gender studies, environmental advocacy, and technological evolution.

The BLEU gaps are statistically significant per bootstrap resampling tests (p<0.05). Fig. 3 illustrates the convergence in BLEU over interactive iterations on the News Commentary dataset. iNMT attains higher quality translations with fewer user interactions compared to baselines.

Next, we evaluate the TER in Table 3. Again, it achieves

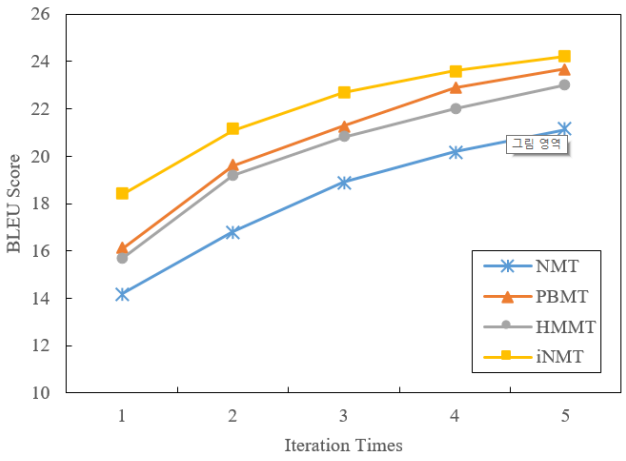

Fig. 3. BLEU score vs. iterations on news commentary test set.

Table 2. BLEU scores for different MT systems.

Methods	IWSLT	Europarl	News commentary	WMT
NMT	34.21	32.15	21.32	18.24
PBMT	35.61	33.82	22.03	19.51
HMMT	35.12	32.87	21.68	18.92
iNMT	36.92	34.73	23.17	30.76

Table 3. TER scores comparing MT outputs to references.

Methods	IWSLT	Europarl	News commentary	WMT
NMT	0.628	0.521	0.736	0.682
PBMT	0.584	0.503	0.712	0.641
HMMT	0.601	0.517	0.729	0.673
iNMT	0.552	0.492	0.698	0.635

the lowest TER across datasets, demonstrating that it better matches ground truth references. The results confirm that the proposed iNMT method produces higher-quality translations than baselines given the same training data.

4.3.3. Results on Human Effort

A key benefit of interactive MT is reducing human effort during translation. We measure effort using keystroke and mouse click metrics. Table 4 shows the average number of word-level keystrokes required per sentence. iNMT requires significantly fewer user keystrokes compared to other systems. For example, on Europarl, iNMT reduces effort by 43% over NMT.

Fig. 4 again shows the keystrokes converging faster for INMT over iterations. The proposed method provides efficient interaction. For mouse clicks required to select valid segments, iNMT naturally incurs higher usage than non-interactive NMT. However, compared to HMMT, it is more efficient by selectively validating segments that maximally improve the hypothesis.

According to the above, the segment-based iNMT method offers significant improvements over existing prefix-based IMT methods. Users can validate multiple segments of the machine translation hypothesis, not just left-to-right prefixes, which allows for correcting the most critical errors first, regardless of position. The experiments on standard datasets show the segment-based method requires fewer user keystrokes for correction than prefix-based methods.

Table 4. Average user keystrokes per sentence

Methods	IWSLT	Europarl	News commentary	WMT
NMT	14.2	16.4	19.7	21.3
PBMT	11.6	14.2	17.8	18.4
HMMT	10.9	13.7	17.1	18.2
iNMT	8.4	9.3	12.1	13.6

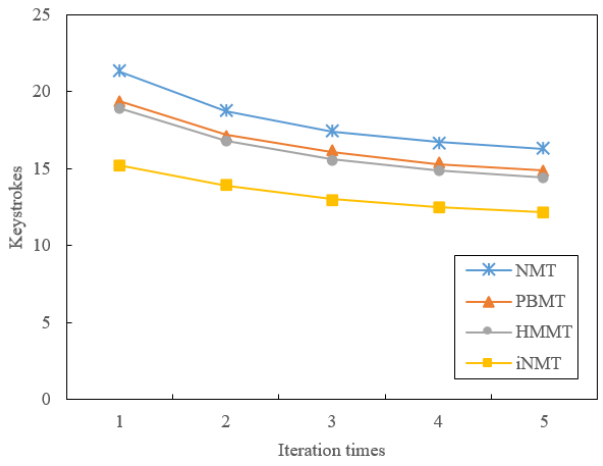

Fig. 4. Keystrokes vs. iterations on WMT En-Fi.

For example, on the WMT En-Fi test set, the segment-based approach needed 13.6 keystrokes per sentence versus 18.4 for prefix-based interaction. Based on the results, segment-based iNMT achieves superior BLEU scores across test datasets, indicating it produces more accurate translations than prefix-based alternatives. On IWSLT, it attained 36.92 BLEU versus 35.61 for prefix interaction. Validating arbitrary segments aligns better with human post-editing workflows than rigid left-to-right correction. Therefore, the flexible validation of multiple segments enables more efficient guided error correction, reduces human effort, improves translation accuracy, and provides a more natural interactive translation experience. The empirical results demonstrate the significant benefits of the segment-based protocol over existing prefix-based methods for interactive NMT.

Integrating the iNMT method into the broader tapestry of HCI, ecofeminism, and the interpretations of Deleuze's "becoming-woman" offers a unique opportunity to bridge technical advancements with philosophical and cultural considerations. (i) Evolving HCI paradigms. The iNMT method facilitates a more collaborative interaction between humans and machines. This echoes Deleuzian ideas of "becoming," where interactions are not static but evolve, and the boundaries between user and machine are more porous. (ii) Empowering marginalized voices. Ecofeminism critiques the domination of nature and women. By allowing real-time user guidance, iNMT provides users more control over translations, potentially amplifying marginalized or traditionally silenced voices. This democratizing aspect can be seen as an alignment with ecofeminist ideals. (iii) Dynamic identities in literature. In contemporary literature, characters often grapple with fluid identities. It can be a metaphorical tool to explore these fluidities, mirroring the continuous feedback loop and interaction in the translation process. (iv) Reducing technological alienation. One of the concerns of ecofeminism is the alienation brought about by certain technologies that distance humans from nature. A more interactive and intuitive AI, such as iNMT, can reduce this alienation feeling, creating a more harmonious and intuitive interaction. (v) Challenging binary oppositions. Deleuze's "becoming-woman" challenges strict binary oppositions. iNMT, in allowing user interactions to shape translations, also moves away from the idea of a fixed, binary output (correct/incorrect) to a more fluid, evolving outcome, parallel challenges to strict dualisms in gender and nature. (vi) Expanding the literary AI narrative. As AI plays a more significant role in literary explorations, systems like iNMT can influence how narratives are constructed, dissected, and even translated. In turn, it offers a more nuanced approach to themes like "becoming-woman," where the narrative is not static but is continuously evolving. The positive impacts of such an iNMT method, when viewed through the lens of HCI, ecofeminism, and Deleuzian philosophy, lie in its po-

tential to democratize interactions, amplify marginalized voices, and offer new tools and metaphors for exploring fluid identities in contemporary literature and beyond.

V. WAYS FORWARD AND CONCLUSIONS

This paper has explored the fertile intersection between the philosophy of Deleuze, ecofeminist thought, and advancements in AI through the lens of HCI and contemporary literature. Integrating the iNMT method facilitated and enriched this interdisciplinary dialogue by enabling the translation and widespread dissemination of relevant literary works.

While this paper spans a broad interdisciplinary scope across philosophy, feminism, literature, and machine translation, we can see the merits of narrowing the focus to allow a more cohesive argument. However, our core contribution lies in the integration and dialogue between these diverse domains. Each field offers unique perspectives that enrich examining themes like identity, bias, and technology through the interplay of concepts from Deleuze, ecofeminism, and AI systems. While a narrower scope would provide depth, it risks losing the valuable cross-pollination of ideas we aimed to catalyze. Bringing disciplinary lenses into conversation fosters novel directions and insights that siloed investigations would lack. Indeed, integration across such breadth sacrifices detail within each domain. However, the synthesized whole is greater than the disciplinary parts - the interdisciplinary approach creates fresh connections and directions for exploration. Our goal is not mastery of each field but showcasing their synthesis to spur innovative, humanistic AI research and design.

5.1. Current Limitations

This paper aims to bridge the gap between HCI, Ecofeminism, and Deleuze's "becoming-woman" in the context of AI and contemporary literature. While the research offers valuable interdisciplinary insights, it is essential to acknowledge its limitations for a more comprehensive understanding. One of the most significant limitations is the scope of the literature reviewed. This paper primarily focuses on English-language literature, which inherently restricts the cultural and linguistic diversity of the works analyzed. Simultaneously, this limitation could affect the generalizability of the findings and overlook significant contributions from non-English literary traditions and technological developments. Additionally, this paper faces challenges related to its interdisciplinary nature. Merging concepts from HCI, Ecofeminism, and Deleuzian philosophy is a complex task that requires a nuanced understanding of each field. While this paper attempts to integrate these perspectives, it may only capture some of each discipline's intricacies and subtleties.

Methodologically, this paper relies on qualitative analysis, which, although rich in interpretive value, has its constraints. The findings are inherently subjective and may not be universally applicable. A more robust approach with quantitative metrics could offer a more comprehensive view of the issues. On the technological front, this paper critiques existing AI systems. However, it needs to provide a practical implementation that embodies the interdisciplinary framework proposed, leaving a gap between theoretical critique and practical application, which future research could aim to fill.

Another limitation to consider is the rapidly evolving landscape of AI technologies. This paper discusses current systems and practices, but given the speed at which AI is advancing, some of these technologies may soon become obsolete, raising questions about the long-term relevance of the study. Additionally, ethical considerations also present a limitation. While the paper advocates for more ethical and inclusive AI systems, it must delve deeper into the practical and ethical challenges of implementing Ecofeminist and Deleuzian principles in real-world technologies. Lastly, this paper analyzes a limited number of literary works, which may need to fully capture the diversity of themes and perspectives in contemporary literature. A more extensive analysis could provide a richer understanding of how literature engages with the themes of HCI, Ecofeminism, and Deleuze's "becoming-woman."

By acknowledging these limitations, this paper aims to pave the way for future research to address these challenges and contribute to a more comprehensive understanding of the interdisciplinary issues it explores.

5.2. Deleuze's Poststructuralist Notion of "Becoming" in Human-AI Interaction

A core tenet resonating through Deleuze's oeuvre is the notion of "becoming" - a constant flux and transformation process whereby entities are in a continuous state of flow rather than being defined by static identities. As this paper has articulated, this concept finds renewed significance in the context of human-AI interaction and advanced machine learning systems. With intelligent algorithms now capable of responding to users, making predictions, and exhibiting creativity, the boundaries between human and machine intelligence are increasingly blurred. Deleuze's non-binary perspective allows us to re-examine notions of identity and humanness in this landscape where AI encroaches into territories once considered exclusively human. Notably, "becoming-woman," emphasizing fluidity and deterritorialization, resonates strongly. When users interact with AI systems like chatbots, virtual assistants, or machine translation tools, human and machine identities are destabilized. A re-

ciprocal process of mutual adaptation and evolution is occurring, echoing the Deleuzian worldview where change is the only constant. The human user adapts their language, requests, and queries based on the machine's capabilities, moving away from their isolated perceptions. Meanwhile, the machine agents continuously update and refine their responses based on human inputs. Their identities evolve with each other.

This coupling of human intelligence with AI has ramifications for how we perceive consciousness, autonomy, and even the meaning of life in an increasingly technologized world. It calls for a paradigm shift away from dualist thinking and its inherent hierarchies. Like Deleuze's "becoming-woman" deterritorializes gender, "becoming-machine" indicates the dissolution of the human vs. technology divide, which is not to advocate a techno-utopianism but instead to allow a productive reimagining - one where we do not see technology as an opposing 'other' but as part of our own continually transforming assemblage.

5.3. Ecofeminist Principles for Ethical AI

In contrast to Deleuze's individualistic notion of transformation and unbridled flows, ecofeminism puts forth a more holistic worldview centered on interconnectedness, inclusion, and collective well-being. This paper has proposed adopting ecofeminist thought as an ethical framework to evaluate and transform AI along more just lines. The domination and exploitation of nature under patriarchal systems parallel the suppression of women's voices and perspectives. Ecofeminists expose these interlinked oppressions embedded within existing power structures. When examining the development of modern AI systems, we find similar patterns of marginalization, whether in terms of gender biases encoded in datasets or unequal access to technology along economic lines. An ecofeminist lens sheds light on these inequities and provides a moral foundation to reorient technology toward human flourishing and ecological sustainability radically.

Some concrete ways in which AI systems could integrate ecofeminist values include diversifying development teams to mitigate gender and ethnic biases, ensuring transparency and accountability in algorithmic decision-making, de-emphasizing metrics of efficiency and predictive accuracy over more holistic humanistic aims, designing interfaces that foster communal connections rather than isolation and disembodiment, centering the voices of marginalized user groups through participatory design, and applying AI innovations to tackle pressing environmental and social justice issues, which is not to propose that ecofeminism alone can resolve the complex ethical quandaries surrounding AI. Integrating ecofeminist thought into AI can be complicated by differences between the decentralized ecofeminist movement and the heavily technocratic domains of computer science. There is a need for nuance in translating broad philosophies into technical practices. However, even if imperfectly realized, ecofeminism provides a compelling polestar to guide AI systems towards greater wisdom, empathy, and justice. Its values are very much complementary to emerging AI ethics paradigms.

5.4. Interactive AI for Literature Translation and Dissemination

This paper proposed an interactive neural machine translation method to facilitate translating literary works related to Deleuze and ecofeminism across global languages and cultures. Interactive AI like this allows bidirectional feedback between the user and the system, enabling real-time guidance rather than one-shot static translations. From the BLEU, TER, and human evaluation results, the proposed interactive NMT model significantly improved translation quality and reduced human effort compared to non-IMT baselines, demonstrating the feasibility of interactive protocols to integrate human knowledge into AI systems dynamically.

There are a few aspects of the proposed iNMT method that could help reduce biases and give users more autonomy. (i) Real-time user feedback. Allowing users to guide translations interactively allows problematic passages or biases to be corrected in real-time based on the user's judgment, which is difficult in static machine translation. (ii) Maintaining original context. iNMT attempts to maintain the original textual context and connotations, which can reduce inadvertent distortions. (iii) Confidence filtering. Based on model confidence scores, biased segments less likely to match the source are automatically filtered out. (iv) Training process. The simulated interactive training regimen teaches the model to integrate human feedback signals, making it more responsive to user guidance.

This iNMT method accelerates the dissemination of ideas across linguistic barriers by allowing readers worldwide to engage with texts related to "becoming-woman," ecofeminism, and contemporary philosophy. The symbiotic collaboration between user and machine mirrors the process of "becoming" that Deleuze theorized - emerging collectively through a dialectical dance rather than in isolation. The user updates the system, the system responds accordingly, and in this cyclic process, new understandings may blossom. Additionally, the ability to guide translations interactively gives users greater autonomy over the rendering of texts, reducing biases that AI systems may inadvertently introduce, facilitating the dissemination of marginalized narratives, and allowing ecofeminist thought to permeate into diverse cultures. Literature translated through AI becomes imbued with the lived experiences of the users. This

helps disseminate diverse ecofeminist narratives. Over time, their integration into the AI ecosystem via research, ethics boards, and policymaking can shape technology to align with ecofeminist ideals.

However, we are still limited by the availability of quality digitized source texts. Digitizing and processing literary materials requires significant effort to train neural translation models. There are also gaps in low-resource languages where high-quality AI systems still need to be developed due to data constraints. As such, while interactive neural translation holds promise, substantial work remains to make diverse literature accessible through ethical AI.

5.5. Fiction and Poetry as Explorations of "Becoming"

In analyzing contemporary literature through a Deleuzo-Guattarian lens, we find profound resonances with the philosophy of "becoming" at both thematic and structural levels. Fiction abounds with characters contending with mutating identities and evading stabilizing definitions – thematically aligned with "becoming-woman" and its deterritorializing ethos. Techniques like nonlinear narratives, multiple conflicting viewpoints, and stream of consciousness similarly mirror Deleuze's anti-foundationalist perspectives. For instance, Michael Cunningham's Pulitzer Prize-winning novel 'The Hours creatively transforms Virginia Woolf's modernist touchstone 'Mrs Dalloway' by fluidly shifting between characters, periods, and intertextual references. The very act of literary appropriation-recreation channels Deleuze's conception of art as an act of creative repetition, not sterile imitation. Readers trace the ripple effects of a single novel across decades, with characters continually interpreting and reinterpreting its resonances anew based on their positionality.

Deleuze's thought also opens up new lenses on poetic traditions. The relationship between the reading subject and the poetic object is no longer some dualistic confrontation but a dialectical fusion where the reader and text mutually transform. In works like Anne Carson's 'Autobiography of Red,' mythic characters like the monster Geryon and the hero Herakles are recast in postmodern settings, destabilizing their identities and revealing the constructed nature of historical and literary narratives. Like Deleuze's flows of becoming, the poetic image is revealed as autonomous, self-generating, and self-transforming when unfettered. This paper has only scratched the surface of analyzing contemporary literature through a Deleuzo-Guattarian prism. Entire dimensions around themes of post-humanism, digital realities, automation, and artificial agency could be explored as literal embodiments of "becoming" - where characters shed the illusion of fixed individuality. Their identities dissolve into ceaseless rivers of data. Translating such works to propagate perspectives on AI's transformational nature is an area ripe for future literary critical engagement.

5.6. Towards Smart AI: Limitations and Future Directions

While this interdisciplinary synthesis has provided fertile ground, certain limitations temper any techno-utopian idealism. Significant gaps remain between speculative philosophies, ethical principles, literary metaphors, and engineer ing practices. Digital networks enabled by AI deepen access but also pose threats of surveillance, control, and weaponization by state or corporate powers. Hard philosophical, policy, and technical problems persist around aligning AI with human welfare. We should remain vigilant about the unintended consequences of seemingly innocuous improvements to existing systems. With IMT, does the guise of neutrality mask issues around knowledge extraction from marginalized communities to benefit dominant players in the AI ecosystem ultimately? What biases are reinforced through literary translations, even unconsciously? There are no easy answers, but sustained ethical engagement is necessary.

Moving forward, this points to some promising areas for further cross-disciplinary investigation bridging humanistic inquiry with AI advancements.

- How can critical literary perspectives actively shape AI research to address the dangers of dehumanization? The humanities provide crucial lenses to re-center ethics and social concerns.
- Can the metaphors and aesthetic principles from arts & literature inform more creative, socially aware AI? How can knowledge representation itself be reinvented?
- Where and how should we implement participatory design, community oversight, and other collaborative initiatives to make AI development more democratic rather than top-down?
- What policy and regulatory structures are required to balance innovation with caution to guide beneficial AI evolution? How can we mobilize broad accessibility while addressing risks?

We propose reconsidering core assumptions in AI knowledge representation based on literary perspectives. For instance, dynamic metaphors of growth, transformation, and nonlinearity could inform architectures beyond static, modular pipelines. Academic notions of ambiguity, imagination, and symbolic understanding could shape techniques beyond paradigms focused on big data and statistical correlation. The permutations at the nexus of philosophy, ecofeminism, literature, and AI systems contain uncharted possibilities to move toward technology that enlightens and empowers. With wisdom and care, our AI assemblage can

become one where ethics and innovation harmonize through active collective "becoming."

DATA AVAILABILITY

All data is available upon the reasonable request.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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AUTHORS

Wanjin Dong obtained her Master's degree in English Literature from Zhengzhou University in 2014 and began pursuing a Ph.D. in English and American Literature at Chungbuk National University in South Korea in 2020. She is currently a Junior Lecturer at Nanyang Medical College. Her research interests include AI, HCI, and American literature.

Soonbae Kim is currently a professor at Chungbuk National University. His research interests includes literature analysis (Criticism and Theory), AI applications, etc.

Adam Slowik is an author or co-Author of more than 100 refereed articles in international journals, two books, and conference proceedings, including one invited talk. His research interests include soft computing, computational intelligence, bio-inspired optimization algorithms and their engineering applications.

Jianhui Lv is working at the Pengcheng Lab., China as an associate professor. His research interests include AI, IoT, CHI, smart city, etc. He has published more than 50 papers. He has served as the leader guest editors in several international journals.