A Needle in a Haystack

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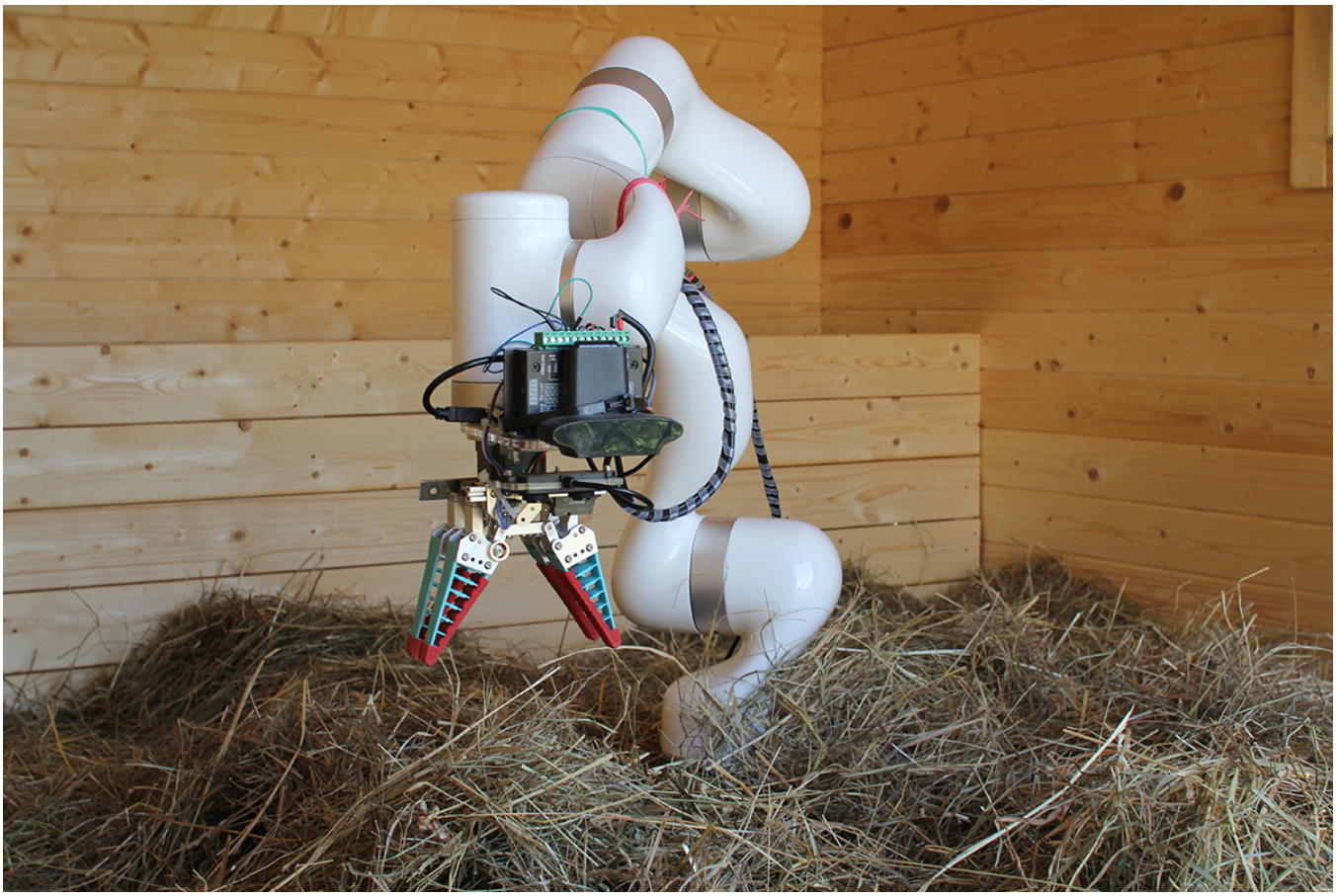

Figure 1: Robotic art installation *A Needle in a Haystack* (2024) ©Varvara & Mar.

Abstract

A Needle in a Haystack is a robotic art installation that explores the intersection of robotics, artificial intelligence, big data, and environmental sustainability. Drawing inspiration from the idiom, the project features a robot tasked with finding a hidden needle in a haystack—a metaphor for the challenges AI systems face in locating critical information within vast datasets. This work questions the myth of AI as an omnipotent "black box" and highlights its reliance on human labour and resource-intensive computation. The installation engages with the limitations of large language models (LLMs) in handling extensive contexts, referencing contemporary research that exposes their struggles with big data. It also delves into the increasing computational power and energy demands required to train these systems, juxtaposed against the urgent realities of the climate crisis. By drawing attention to modern AI's labour, energy, and environmental costs, *A Needle in a Haystack* prompts viewers to reflect on the ethical and ecological implications of technological advancement in the deep learning era.

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CCS Concepts

• **Applied computing** → **Media arts**; • **Computing methodologies** → **Artificial intelligence**.

Keywords

Robotic art, media art, creative AI, critical AI, installation, needle in a haystack, LLM, big data, climate crisis, sustainability, DL, AI ethics

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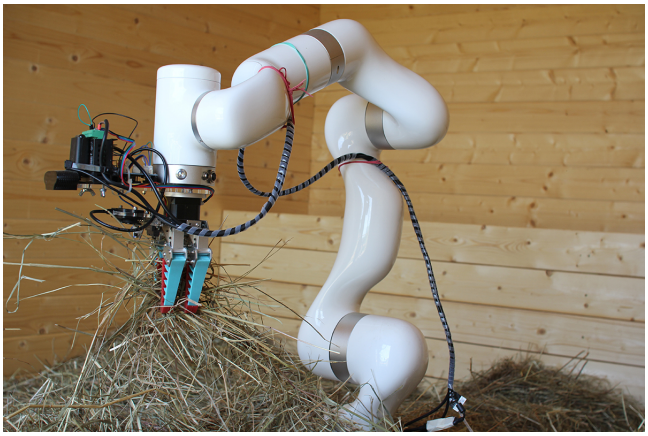

Figure 2: Robot picking up hay. ©Varvara & Mar.

1 Introduction

The phrase "finding a needle in a haystack" stands for a very complex, if not impossible, task. Italian artist Sven Sachsalber literally put this idiom to the test in a 2014 performance at Palais de Tokyo in Paris, where he spent 18 hours sifting through a haystack to locate a single hidden needle[1]. But in an age dominated by deep learning and artificial intelligence, this begs the question: is this idiom still valid for machines?

We explore this question in our robotic art installation, *A Needle in a Haystack* (Fig. 1-3). At the heart of the piece operates a robot arm within a mound of hay (Fig. 3), tasked with finding a hidden needle. Its success is signalled by the ringing of a sheep's bell, creating a moment of triumph—or perhaps futility—depending on the viewer's perspective. This project challenges the boundaries of what machines can achieve, questioning the myth of artificial intelligence as an omnipotent and infallible "black box." Scholars such as Kate Crawford argue that AI is neither truly artificial nor intelligent but rather a product of human labour, data, and biases [2]. Jeff Bezos sarcastically coined the term "artificial artificial intelligence," [12] underscoring its reliance on underpaid human crowd workers. Beyond its technological implications, *A Needle in a Haystack* also mediates humanity's relationship with the natural world. By juxtaposing the precision of robotics with the organic chaos of a haystack, the piece invites viewers to reflect on how our technological ambitions intersect—and often clash—with our environment. It also poses critical questions about our increasing reliance on technology: Is it always the right path forward? And at what cost?

[1]https://www.instagram.com/welcome.jpeg/p/DABpuOmvaKV/?img_index=8

2 A Needle in a Haystack - The Problem in the Age of Large Language Model

The advent of large LLMs, such as ChatGPT, has made the needle-in-a-haystack metaphor even more relevant. These systems grapple with locating specific, relevant information within vast datasets. In essence, the modern Turing test for AI might well be the Needle in a Haystack test: Can a machine identify the critical piece of information hidden within a sea of data?

OpenAI's GPT-4, for instance, boasts a context window of up to 300 pages (128k tokens), enabling it to process and analyse vast amounts of text. However, research reveals limitations. Liu et al.'s paper "Lost in the Middle: How Language Models Use Long Context" demonstrates that models like GPT-3.5 Turbo, Claude-1.3, and others often struggle to retrieve relevant information when buried within the middle of a long text [11] . Similarly, recent experiments by Greg Kamradt highlight that even GPT-4 can lose its way [10], though improvements are evident. While models are becoming more adept at navigating larger datasets, they still falter in extreme scenarios, reminding us of the persistent challenges big data poses. The scale of these challenges grows alongside the datasets themselves. As Xiag-Gen Xia describes: "People are using existing mathematical methods, but for big data problems, we need something different, and what we need will vary with the application. Big data is about more than just numbers." [14] He describes a big data problem: finding a needle in the ocean, which is the corresponding idiom to 'finding a needle in a haystack' in Asian cultures. This raises critical questions: How much computational power is needed to train machines to find these proverbial needles in ever-expanding haystacks? And as data grows larger, how sustainable is our current trajectory? The environmental and resource implications of scaling AI technologies cannot be ignored. While advancements in efficiency are being made, the energy demands of these systems remain significant—and are likely to increase as big data becomes even bigger.

3 Methodology

As artists, we have been documenting the evolution of our practice while exploring creative AI[6, 7]. Our journey began with the generation of art videos using GANs[4] followed by the creation of speculative[8] and interactive experiences[13] and the production of AI-infused ceramic sculptures[5][9]. Most recently, our practice has evolved toward agentic AI, where a robotic arm functions as the physical embodiment of deep learning systems.

At first glance, orchestrating a robotic arm to search for a needle in a haystack seemed like a straightforward task. However, in practice, it was a complex and multifaceted challenge.

Figure 3: An installation view of *A Needle in a Haystack*. ©Varvara & Mar.

Figure 4: An image of hay depth with the MiDaS model. ©Varvara & Mar.

Given constraints such as budget, real-time control requirements, and safety considerations, we opted to use a collaborative robot arm. We chose the uFactory 850 robot for the installation, which allows real-time control through programmable code in Python.

A specialised gripper was required to enable the robot to handle and manipulate hay effectively. We developed a custom solution: a gripper with four flexible fingers, equipped with multiple sensors. These sensors provided crucial feedback, including hay distance, gripper state (open or closed), and camera feed for visual confirmation of whether a needle was detected on the magnet, using an AI approach based on the Tiny Visual Language Model called Moondream2. A camera attached to the gripper played a critical role in identifying the needle. The gripper is controlled via Arduino and interfaced with the main system through custom-written code.

The robot workflow was designed as a repetitive cycle. It would pick up hay from an untapped area (Fig. 2), carry it to a magnet, attempt to drop any attached needle, discard the remaining hay, and then return to the magnet to check if a needle had been left behind (Fig. 5). If the robot detected a needle, it would ring a bell to signal success (Fig. 5). If no needle was found, the robot would calculate the following optimal location to collect hay and repeat the cycle. To enhance efficiency and precision, we implemented AI-based monocular depth estimation to analyse the distribution of hay, identifying areas with more or less hay (Fig. 4). Traditional depth cameras and standard computer vision techniques proved unsuitable due to hay's irregular and non-solid nature. This bespoke approach allowed the robot to navigate the complexities of haystack manipulation.

As we learned from our previous robotic art installation Dream Painter[1, 3], achieving full autonomy was the most challenging aspect of the project. Developing a system capable of distinguishing hay from a needle, keeping track of previously visited areas,

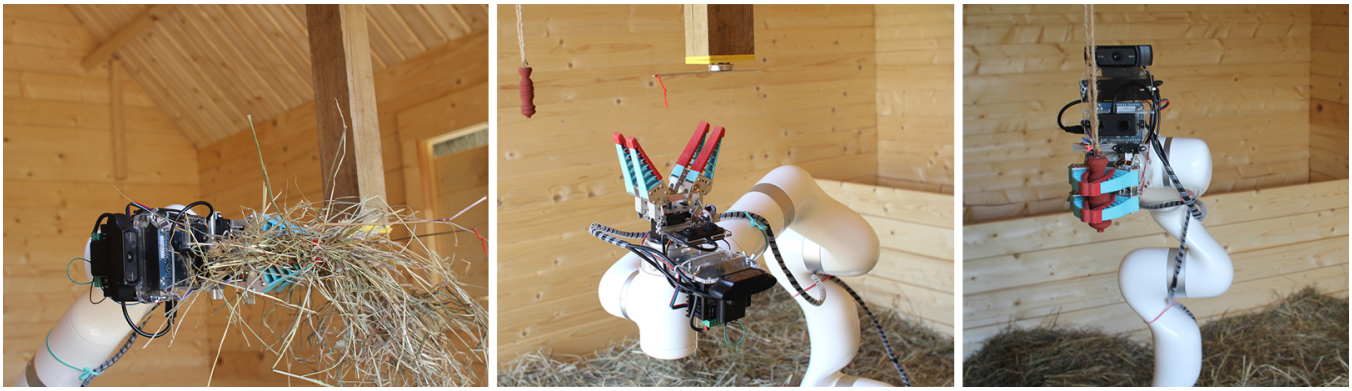

Figure 5: From left to right: a robot attempts to place a needle near a magnet, checks to confirm whether the needle has been detected, and finally rings a bell to signify its success in finding the needle. ©Varvara & Mar.

managing the placement of hay, and identifying key landmarks such as the magnet and the bell required significant computational and programming effort. Unlike industrial robots, which typically follow preprogrammed paths or repetitive animations, this installation required real-time decision making and situational awareness, an ambitious leap toward robotic 'intelligence'.

A Needle in a Haystack was co-commissioned by Wild Bits and Europe Capital of Culture Tartu2024. We did a 15-day artist residency in July 2023 during the research and development phase at DDTLab, led by Maša Jazbec, in Trbovlje, Slovenia. The artwork was first exhibited as part of the outdoor exhibition Wild Bits, May 25 - Sep 15 2024, in southern Estonia. *A Needle in a Haystack* was also shown at KiKK Festival 2024 in Namur, Belgium with kind support from the Estonian Cultural Ministry, and in Tartu Christmas City during December 2024.

4 Conclusion

A Needle in a Haystack reflects the growing challenges of the deep learning era, where the scale of data is vast, models are increasingly complex, and the demand for computational power is ever-rising. At the same time, we live in an age of climate crisis, making these energy-intensive pursuits more ethically and environmentally significant than ever. This artwork highlights the immense effort, resources, and ingenuity required to sift through big data and extract meaningful insights—the proverbial needle. The installation's robotic system mirrors the dilemmas faced by modern AI, navigating the complexities of large datasets and balancing precision, efficiency, and autonomy. Our project draws attention to the real-world implications of these challenges, emphasising the unseen costs of AI development in terms of energy consumption and environmental impact. It invites viewers to question the trajectory of technological advancement and consider whether our reliance on increasingly powerful models aligns with a sustainable future. In conclusion, *A Needle in a Haystack* stands as a metaphor for the contemporary tension between technological ambition and ecological responsibility, urging us to reflect on the paths we choose to pursue progress.

Link to the project: https://var-mar.info/a-needle-in-a-haystack/

Acknowledgments

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