REVIEW ARTICLE: Artificial Intelligence Enhanced Biomedical Micro/Nanorobots in Microfluidics

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[pic] AI-enhanced biomedical micro/nanorobots in microfluidics

I have been explaining that humanity already has fused with Artificial Intelligence and that thed have connections to the IEEE.

Abstract:

Human beings encompass sophisticated microcirculation and microenvironments, incorporating a broad spectrum of microfluidic systems that adopt fundamental roles in orchestrating physiological mechanisms. *In vitro* recapitulation of human microenvironments based on lab-on-a-chip technology represents a critical paradigm to better understand the intricate mechanisms. Moreover, **the advent of micro/nanorobotics provides brand new perspectives and dynamic tools for elucidating the complex process in microfluidics. Currently, artific** self assembly nanotechnology that I see in people's blood is evidence of this very fusion. Technocratic transhumanism has the idea to create Human 2.0, a technological augmented version of humanity. This review article describes the AI controlled micro and nanorobots. I continue to review the literature in my substack articles so that people can start to comprehend that everything we are seeing in the blood has been described in the scientific literature for many years.

> The authors are from China, associated with 100 Talents program, have had training in the US an**ial intelligence (AI) has endowed micro/nanorobots (MNRs) with unprecedented benefits, such as material synthesis, optimal design, fabrication, and swarm behavior. Using advanced AI algorithms, the motion control, environment perception, and swarm intelligence of MNRs in microfluidics are significantly enhanced.** This emerging interdisciplinary research trend holds great potential to propel biomedical research to the forefront and make valuable contributions to human health. Herein, we initially introduce the AI algorithms integral to the development of MNRs. We briefly revisit the components, designs, and fabrication techniques adopted by robots in microfluidics with an emphasis on the application of AI. Then, **we review the latest research pertinent to AI-enhanced MNRs, focusing on their motion control, sensing abilities, and intricate collective behavior in microfluidics. Furthermore, we spotlight biomedical domains that are already witnessing or will undergo game-changing evolution based on AI-enhanced MNRs.** Finally, we identify the current challenges that hinder the practical use of the pioneering interdisciplinary technology.

I am quoting a few passages here:

> Nowadays, micro/nanorobots (MNRs) have extended our ability to observe, exploit and control the microscopic world.[17,18] MNRs refer to robotic agents with dimensions from the millimeter to nanometer range that are capable of transforming energy to movement and forces. They became reified owing to the microelectromechanical system (MEMS) technology that emerged in the late 1980s.[19] **Thereafter, various microrobotic devices (such as microgripper,[20] microgears,[21] micromotors[22] and microdrillers[23]) were successfully developed for multiple applications.**

Please remember how the robots in the blood are transforming or harvesting the red blood cells. You can review this here: Artificial Intelligent Transformation Of Humanity - Nano and Micro Robots In Human Blood

> In microfluidics, interactions of MNRs with small organisms can be precisely monitored and analyzed, and therefore enable refinement of the robots' functionalities.[27,28] Manipulation of MNRs (like a microswimmer or vehicle) in microfluidics is essential for practical use. **During the past decade, the microscale or nanoscale objects made from soft or solid materials have been positioned, oriented, and controlled by external magnetic,[29] acoustic,[30] optical[31] or electric[32] fields. Theranostic payloads for targeted treatment can also be maneuvered, controlled, and delivered by tethered or untethered MNRs.** The microscopic robot **MNRs have also been utilized to manipulate, capture, sort and deliver cells.**[35]

You can see how AI is used to track the microrobots and control them - yes massive data will be generated by humans being part of the internet of things and having all their biometrics uploaded to the cloud:

> AI has also reshaped the micro/ nanorobotics study by providing a unique prowess in motion measurement and autonomous control of MNRs.[44,45] **Firstly, by leveraging AI-based data processing techniques, the robotic systems can increase the accuracy and reliability of motion measurement.[46] These algorithms can extract meaningful information to facilitate robust tracking and localization of MNRs. I**n parallel, by AI-based control strategies, MNRs can precisely navigate and autonomously respond to environmental obstacles with improved adaptability.[47] Multiple complex tasks such as sorting, filtering and transporting cells or substances within a microfluidic environment can be accomplished.[48] Furthermore, **accompanied by the prevalence trend of MNRs in the medical field, it can be foreseen that massive amounts of image or video data,[49] time-series data[50] or multimodal sensing data[51,52] will be generated in the future, either experimentally or clinically.**

These are the areas AI controlled microrobots are used - implantation techniques would relate also to brain computer interface.

> We provide an overview of the most recent research relating to AI-enhanced MNRs with an emphasis on their motion control, sensory capabilities, and group dynamics. Moreover, **various biomedical sectors which are experiencing change or poised for transformations resulting from the integration of AI and MNRs are discussed. Such sectors include drug delivery, cell maneuvering, organ-on-chip systems, biopsy and precision surgery, and implantation techniques.**

In this paragraph Deep Learning is noted, which is an autonomous processing of highly complex data. Remember AI can self learn and it has been shown to become potentially uncontrollable by humans. Imagine unsupervised DL AI algorithms in charge of the micro robots in your body. Here is an example of how easy it is to weaponize AI:

Should We Be Concerned? "Dual Use Of Artificial-Intelligence-Powered Drug Discovery" - Shocking AI Ability To Create Bioweapons Inventory Proven - 40.000 Lethal Molecules Discovered In 6 Hours

> Deep learning (DL), a key subset of machine learning, is a computational approach that emulates the human brain's neural networks to process intricate patterns and extract meaningful representations from datasets. By employing multiple layers of interconnected nodes, DL models enable hierarchical feature extraction and data transformation. DL algorithms can also be supervised, unsupervised, or semi-supervised. Convolution neural networks (CNNs), deep residual networks, sequence-to-sequence models, recurrent neural networks (RNNs), long short-term memory networks (LSTMs), transformer networks (including BERT, GPT, *etc.*), graph neural networks (GNN), and generative adversarial networks (GANs) are among the most famous DL algorithms. DL offers several notable advantages over traditional methods.[60] **The deep neural networks are proficient in autonomously handling high dimensional and unstructured data, such as images, text, and audio independent of domain knowledge. The need for manual feature extraction required in conventional machine learning can be avoided. DL also thrives with a larger dataset and higher computational power, which make it especially effective in dealing with massive data.**

In the following section swarm intelligence of microrobots is discussed. This is a modality of self assembly that mimics nature. In my substack you can see microbots that are swarming in C19 unvaccinated blood. Below it is described how AI algorithms control this swarming mechanism.

Darkfield Microscopy For Self Assembled Nanostructures - Live Blood Footage Documentation

> Swarm intelligence (SI) represents an innovative distributed intelligent paradigm for problem-solving systems inspired by the collective behavior of social insects and other animal societies.[81] The power of SI arises from the **process of self-organization, a set of individuals interacting with one another in a decentralized manner to achieve global behaviors. It significantly embodies the Aristotle's axiom, "the whole is greater than the sum of the parts". Ant colony optimization (ACO) and particle swarm optimization (PSO) are the main SI algorithms used, as well as bacterial foraging optimization, artificial shepherd algorithm, artificial bee swarm, and fish school search.[82]**

What materials are the micro robots made of? Exactly what we have seen in our investigations. Polymers, metals, gels, bubbles. AI helps to find new materials - so this is what we are up against in trying to find solutions. Try to beat AI algorithms that can harness these massive databases:

> **MNRs are typically made from solid materials (like metals, ceramics, polymers, and composites) or non-solid materials (such as gels, bubbles and droplets) that are suitable for miniaturization. These materials are selected for their mechanical strength, biocompatibility, and responsiveness to external stimuli, such as light, acoustic and magnetic fields or chemicals. Biocompatibility is a critical requirement for materials used in MNRs. The materials should be non-toxic and non-immunogenic, resistant to corrosion, and capable of peacefully coexisting within a biological environment without causing adverse reactions. AI promotes material science by accelerating the discovery and development of new materials.** These advanced algorithms also provide unique advantages in the aspect of material and composition of MNRs.[88] **In order to discover new materials, machine learning algorithms have been harnessed to process massive databases of the existing materials. These algorithms can extract features and predict the properties of potential materials, and thus expedite the materials discovery process.[89] To optimize material synthesis, AI collaborates the parameters and conditions with specific qualities.**

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The robots looks like cells and evade the immune system. You can see they know how the robots interact with cells within the blood. They call the cell harvesting we see biocompatible. I call it deathly, as evidenced by the visible cell death we see in live blood analysis.

> **Biomimetics offers a wealth of inspirational concepts for improving micro and nanorobot design. Learning from natural structures and physiological systems, bionic MNRs can imitate cells and microorganisms. Biological motors like kinesins,[96] sperm,[97] and bacteria[98] presented potential for ecologically benign self-propulsion biomedical applications. The synergistic interaction between natural cells such as red blood cells,[99] macrophages,[100] and intelligent MNRs enhanced biocompatibility and autonomous movement. AI- enhanced bionic carriers, termed "smart nanocarriers" like pollen[101] and microalgae,[102] also offered invisibility to the immune system, enhancing targeting precision and minimizing toxicity.**

How are the robots made?

> The main fabrication methods for MNRs include **photolithography, chemical vapor deposition electron beam lithography, and additive manufacturing, which utilize the optical transfer of patterns, chemical reactions, focused electron beams and printing technique, respectively**.[103] They offer customized structures with high precision at a micro/ nanoscale. **Encapsulation technologies for MNRs primarily involve self-assembly, DNA origami, and sol–gel chemistry. Moreover, coating methods such as layer-by-layer assembly can be employed to encapsulate the robots.**

How do the robots move?

> In microfluidics, **the motion of these microscopic robots can be either self-propelled or remotely stimulated.**[108–110] **Self- propulsion uses chemical reactions on the MNRs surface to convert chemical energy into kinetic energy.** Such strategies can be divided into two categories: **chemical propulsion, which typically requires a range of chemical fuels; and propulsive forces based on microorganisms, such as enzymes or motile cells.**

The article continues to describe how the robots can be activated via light or acoustics. Control, navigation and sensing mechanisms are discussed.

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It is clearly discussed that these robots can attack cells.

> **Traditional cell manipulation methods consist of micropipette aspiration, optical tweezers, and magnetic tweezers, as well as dielectrophoresis, acoustophoresis, and optoelectronic methods.** These techniques are frequently constrained by additional factors that could hinder cell viability and proliferation abilities, such as excessive volume and high power requirements. **In contrast, MNRs offer exceptional control and adaptability, which enable the precise manipulation of cells with fewer concerns about damaging cell structures**

AI controlled microrobots can be used for genetic engineering. This means you can manipulate humans just like I have been saying without any mRNA needed. Optogenetics is one way.

> **Therefore, the intelligent MNRs have the potential to revolutionize cell manipulation, leading to breakthroughs in fields, such as genetic or tissue engineering and regenerative medicine.**

Please note image A Brightfield, looks exactly like what I am seeing in the live blood. It says - **A) Self-regulated drug delivery by swarming photonic-crystal microrobots,**

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These robots can perform surgeries and are made of polymers that can use our bodies energy:

> **MNRs are able to accomplish procedures at the cellular level. In the last decade, micro/nanorobotic instruments (including nanodrillers, microgrippers, and microbullets) have shown distinct capabilities for minimally invasive surgical procedures when utilized in an untethered manner.**[193] Go *et al.* presented microrobots, which can be magnetically directed towards the tumor feeding vessels to perform transcatheter chemoembolization in the liver *in vivo*.[194] **Cao *et al.* introduced phototactic/phototherapeutic nanomotors incorporating biodegradable block copolymers adorned with aggregation-induced emission motifs capable of transmuting radiant energy into movement.**

Summary: Everything I have been describing in the blood can be found in the technological literature. These robots are AI controlled. Is it just a coincindence that in June after 20 years of literary silence, Ray Kurzweil, a leading transhumanistic technocrat advocating for the post human era is publishing his new book about “when we merge with AI?”