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Role of Nanoscience in Artificial Intelligence

Research Project

Submitted to the department of General Science in partial fulfillment of the requirements for the degree of BSc. In General Science

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Supervisor Approval

I support that this research has been completed and written under my supervision and, I agree that it will be presented in its current form for discussion to obtain a bachelor's degree for each student.

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Chapter One

1-1 Introduction

Advances in nanoscience and nanotechnology promise to have major implications for advances in the scientific field as well as peace for the upcoming decades. This will lead to dramatic changes in the way that material, medicine, surveillance, and sustainable energy technology are understood and created. Significant breakthroughs are expected in human organ engineering, assembly of atoms and molecules, and the emergence of a new era of physics and chemistry.

AI is an approach to inculcate human - like thinking into an electronic gadget of any scale. This is an analysis of how human brain as it attempts to solve problems, thinks, learns, decides and works. It is heavily inspired by biological anatomy for the development of prevalent and most effective models, viz., artificial neural networks (ANNs) and other such algorithms . An important AI goal is to improve machine functions related to human intelligence such as reasoning, thinking, and problem solving.

A combination of these two fields can result in great breakthroughs from the fast - paced AI assisted nanotechnology research to creating the state - of - the - art materials, to expand the application area of AI using nanotechnology - based computing devices. Besides merging the two technologies, a combined research can also give a thrust to the study in each discipline, possibly leading to all sorts of new methods to gain insights and communication technologies [1-7].

Chapter Two

2-1 Nanotechnology

We know that atoms gather to form materials in their known state to get iron, gold, diamonds and other known materials and compounds that we use in our daily lives. These materials and compounds are found in nature in their known form. Through scientific studies and research, we got acquainted with its atomic structure and studied its properties to become one of the basic materials in our lives on which industries and technologies are based that make human life easier and more luxurious.

The building block of material is the atom. The atom is infinitesimally small, as if you put 10 million hydrogen atoms side by side, its length is 1 millimeters. American scientist Richard Feynman in 1959 scientist put forward his vision of the possibility of changing the properties of any substance if its atoms were rearranged because the properties of materials depend on their composition and crystal structure, and what Feynman was talking about was as if it was a science fiction that scientists did not believe at the time, because at that time there was no way by which the atom could be moved in the material with a diameter of less than one nanometer and moved from place to place and rearranged.

In the year 1981, the two scientists Heinrich Rohere and his colleague Gerd Bininig the two researchers at IBM invented the Tunneling Microscopy Scanning (STM), which enabled them to directly deal with the single atoms of the material and determine its three dimensions through a very fine needle that can apply negative electric charges to sense the atoms on the surface of the sample under study Figure (2-1) and determine the shape and arrangement of the atoms in it. [1-5]

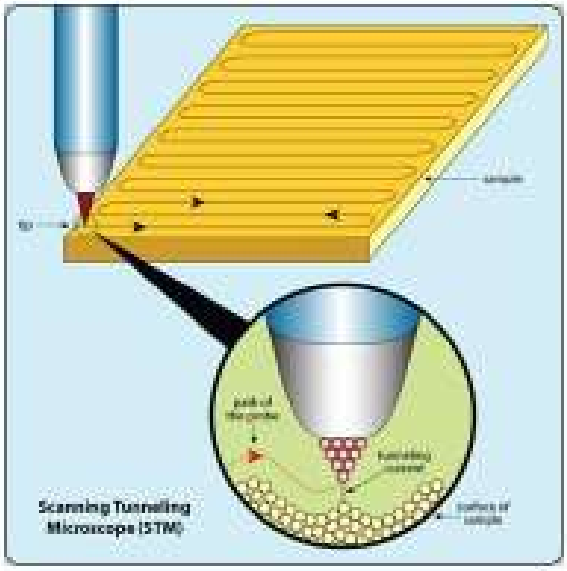

Figure 2.1: Illustrates the idea of scanning tunneling microscope needle work.

Nanotechnology is the fifth generation of electronics in the 21st century. Where the first generation relied on electronic lamps that were used in radio and television sets, and the second generation relied on the transistor, which replaced large electronic lamps with small electronic pieces that enabled From the manufacture of smaller devices with higher efficiency and replaced the technology of electronic lamps with transistors, then entered the third generation, which relied on integrated circuits, reduced the size of many devices and increased their efficiency. The computer and communication devices we use now. [1-5]

2-2 Nano Term

Before we explain what nanotechnology is, let's first get acquainted with the term nano. This term is mainly derived from the Greek word nanos, which means little dwarf and is used to denote one billionth of a meter.

1 centimeter equals one hundredth of a meter

1 millimeter equals one thousandth of a meter

1 micrometer equals one millionth of a meter

1 nanometer is equivalent to one billion (one thousand million) parts of a meter

Hence, we note how small one nanometer is, as a meter is equivalent to 1000 million nanometers, and a nanometer is equivalent to the length of 13 hydrogen atoms next to each other as in Figure (2-2). [1-5]

Figure 2.2: shows the number of nanometers through 13 hydrogen atoms with a diameter of each atom Equivalent to 0.75 nm.

Another example to illustrate the smallness of the nanoscale is the diameter of a human hair, which is on average 100 micrometers, which is equivalent to on the nanometer scale equivalent to 100,000 nanometers, and the diameter of the red blood cell is 2.5 micrometers, which is equivalent to 2500 nanometers, while the length of bacteria is 1 micrometers, which is equivalent to 1000 nm.

The nanometer unit was used as a unit of measurement for the length of very small things that can only be seen by electron microscopy. It is used to express the dimensions and radii of atoms and as a measure of cells and microscopic particles.

2-3 Types of AI

Artificial intelligence can be categorized into four types [6,7]:

a) Reactive AI uses algorithms to optimize outputs based on a set of inputs. Chess - playing AIs, for example, are reactive systems that optimize the best strategy to win the game. Reactive AI tends to be fairly static, unable to learn or adapt to novel situations. Thus, it will produce the same output given identical inputs.

b) Limited memory AI can adapt to past experience or update itself based on new observations or data. Often, the amount of updating is limited (hence the name), and the length of memory is relatively short. Autonomous vehicles, for example, can "read the road" and adapt to novel situations, even "learning" from past experience.

c) Theory - of - mind AI are fully - adaptive and have an extensive ability to learn and retain past experiences. These types of AI include advanced chat - bots that could pass the Turing Test, fooling a person into believing the AI was a human being. While advanced and impressive, these AI are not self - aware.

d) Self - aware AI, as the name suggests, become conscious and aware of their own existence. Still in the realm of science fiction, some experts believe that an AI will never become conscious or "alive"

2-4 Link between Artificial Intelligence and Nanoscience

The development of modern science and technology depends entirely on information, nano, and biological sciences. The thought of biology, artificial intelligence and nanotechnology convergence promoting a scientific and technical

revolution has been lingering for more than a decade now. Although, this multidisciplinary research expected integration is still in progress. Knowledge of engineering, chemistry and physics is combined by nanotechnology meanwhile artificial intelligence highly depends on the biological inspiration for developing some of its most effective paradigms, for instance, evolutionary algorithms or neural networks.

If the link between current artificial intelligence and nanosciences is bridged then it is capable of boosting research in these disciplines and offering communication technologies and information to the new generation which will impact our society on a large scale, and possibly will provide the means for the merging of biology and technology [6-8].

Unknown or complex data or functions can be represented and generalized by Machine learning methods, and when it comes to the treatment of interacting parameters, they are very efficient. The machine learning methods contain Methods like artificial neural networks (ANNs), an interconnected node - set in which an unsupervised or supervised algorithm determines the connection weights for learning input - output functions of these types. Search and optimization problems are being solved by other types of evolutionary or genetic algorithm - based bio - inspired AI paradigms [8,9].

In addition, nano computing, nanodevices, and nanomaterials provide increased power as effective architectures for implementing machine learning methods and AI, and generally, computer science can get an advantage from that increase in power. This bidirectional interaction between nanotechnology and AI has various usages and applications.

Chapter Three

3-1 Artificial Intelligence's Application in Nanotechnology.

Artificial intelligence has been an increasingly growing area for many decades now, not just within itself where the areas of Machin learning, Deep learning, and artificial neural network work simultaneously, but also in the number of fields and industries that they are now prevalent in. Nanoscience and nanotechnology are the study and application of tiny things. there are some growing areas where AI converges with nanotechnology [10]. During the last decade, there has been increasing use of artificial intelligence tools in nanotechnology research. In this paper, we review some of these efforts in the context of interpreting scanning probe microscopy, simulations, nanocomputing, food science, chemical modelling, Medical science and Nanobots.

3-1-1- AI in Scanning Probe Microscopy

Scanning probe microscopy (SPM) is the commonly used imaging technique in the nanoworld [10-12]. Numerous strategies that obtain images by the interaction between a pattern and a probe fall beneath this concept. Characterization of the pattern topography is accomplished by using the tunneling current between the pattern and the probe through their interaction. Several techniques have been developed by varying interactions among the tip and the sample, after the invention of nanoscope. SPM is likewise an effective tool for an atomic - scale manipulation.

ANNs are extensively used for the categorization of various behavioral, structural, and physical properties of nanomaterials on the nanoscale, which are used in plenty of applications.

3-1-2 Nanoscale Simulation

One of the major issues which scientists have to face when working at the nanoscale is related to the tool simulation being studied [11,12] as actual optical pictures at the nanoscale cannot be achieved. Images must be interpreted at this scale, and numerical simulations are once in a while the best technique to get an accurate scheme of what is present in the image. Nonetheless, they are still tough to apply in many conditions, and lots of parameters need to be taken into account on the way to get a reasonable system depiction. Here, AI can be useful in enhancing the simulatiom's performance and making them simpler to collect and interpret. The use of ANNs in numerical simulations has been proven to be beneficial in various approaches when operating at the nanoscale. First, the software program can be manually modulated to control the stability between numerical exactness and physical implication.

3-1-3 Nanocomputing

There is a vast diversity of applications that emerge from the mixture of AI and current and upcoming nanocomputing methods [10-12]. Machine learning tactics implemented with the aid of nano - hardware to a certain extent to semiconductor - based hardware can also provide a foundation for a new technology of less costly and transportable era that can comprise high overall performance computing, including programs, sensory facts processing, and control tasks.

The best expectations from the nanotechnology - enabled quantum computing and storage can considerably boost our capacity to clear up very complicated NP - whole optimization dilemma. Such sorts of issues arise in many unique contexts, but mainly those in big data that requires “computational intelligence”. In DNA computing, a lot of variables are in use [12]. This is a scenario in which DNA computing AI strategies are useful for purchasing an ultimate result from a minor preliminary data set, preventing the usage of all candidate solutions.

3-1-4 Food Science

Food science is growing quickly in association with nanotechnology. The food market technology that is vital to hold marketplace leadership within the food processing industry in order to produce reliable, suitable, and tasteful fresh food products, and nanotechnology is the answer. Nanoparticles are used as preservatives and wrapping, respectively. Nanoscale food additives may be used to have an effect on product taste, nutrient composition, shelf life, and texture; may be used even to pick out pathogens; and may act as signs of meals‟ quality.

Nanotechnology presents an enormous array of possibilities for the development of recent products and meals‟ system applications. AI strategies are pretty supportive for research and development possibilities for food additives and Chemical modeling A similar revolution has been quietly occurring in the world of chemical modeling. Chemical modeling simulates how molecules will interact with each other. It’s used widely in bioscience and drug development. More recently, however, scientists have begun using the same modeling techniques to better understand the behavior of materials at the nanoscale and thereby have been able to improve their efficiency and efficacy.

Neural networks have been used for chemical modeling for years, but it's only recently that they've been applied to nanotechnologies specifically towards understanding how nanotech materials behave under real - world conditions. AI is being used, for instance, to understand carbon nanotube structures by quantifying structural qualities like alignment and curvature. Using AIs, scientists and engineers can now minimize the degree of error related to the geometry or size of a system or particle. The most popular approach to doing this is to train an AI model on data emerging from systems whose behavior is already well understood [6-7,12].

3-1-5 Medical Science

Nanomedicine offers new ways for preventing and treating diseases [12,13]. However, reaching the full potential of nanomedicine is still yet to be fully realized. The use of automation is a step in the right direction of manufacturing nanoscale drugs. In order to improve and ensure that nanomedicine will achieve its desired result, computational analysis of large amounts of data must take place. Therefore, the next step is integrating AI and machine learning into the evaluation and formulation of nanoscale drugs. While traditional computational methods require deep understanding of the physical, chemical and biological knowledge to construct relevant and accurate computational models.

Providing large datasets of experimental results related to the subject of study allows the algorithm to produce accurate prediction models that then can be translated into improved nano - formulations. There are multiple areas where machine learning can be integrated into nanomedicine applications. For example, machine learning can be used to improve the understanding of how the structure of a nanoparticle affects its characteristics as well as its interaction with targeting tissues and cells.

Alternatively, the AI subfield can help determine the correlation between drug dosage and therapeutic outcomes [6,12,13].

3-1-6 Nanobots

Nanobots are robots that are microscopic in nature, measured largely on the scale of nanometers. They are currently in the research and development phase, but on realization, they are expected to do specific tasks at the atomic, molecular and cellular level and help in bringing about many breakthroughs, especially in medical science [6,12,13]. Nanobots are also known as nanomachines, nanorobots, nanomites, nanites or nanoids. The circulatory system of living beings is a natural highway for nanobots which will cruise through the bloodstream to the area of distress. They may be used to attach themselves to specific cells, such as cancer cells, and report the position and structure of these tissues. Nanobots can be considered to be a machine version of a bacteria or virus. They can be biological or synthetic but are adapted to perform preprogrammed tasks at the atomic level. They are expected to aid in research related to cancer, AIDS and other major diseases as well as in helping brain, heart and diabetes research. Other applications where nanobots can potentially be of use are in aerospace, security, defense, electronics and environmental protection [6,12,13].

3-2 Nano Science and AI in the future

There are bright and dark spots in the future of nanotechnology. On the one hand, the sector is expected to grow globally, driven by technological advances, increased government support, increased private investment and growing demand for smaller devices, to name a few. However, the environmental, health and safety risks of nanotechnology and concerns related to its commercialization could hamper market expansion. Artificial Intelligence has immensely benefited modern healthcare. Predictive analytics have helped foreseeing health issues, reduce medical cost, and market medicines. Disease diagnosis and decision making have been relatively simplified using image processing and machine learning. In addition, humanoid robots and precision machines have supported doctors during surgeries. Nanotechnology has influenced cancer research and a major aspect has been developing effective and efficient drug delivery systems based on nanoparticles. Artificial Intelligence, and Micro - and Nano - electrochemical systems (MEMs and NEMS) [6,12,13] have worked in collaboration to assist doctors by developing algorithms and tracking the path of the transmitters attached to the nano - formulated drugs.

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