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**WORKSHOP ON: RESTRUCTURE & IMPROVEMENT OF
ACTIVITIES ON 31.10.2023**



**SCIENCE POPULARIZATION PROGRAMME AT HAJIRAHIMIAN GOVT.
HIGH SCHOOL, BRAHMABARADA, JAJPUR ON 04.11.2023**





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Odisha Bigyan Academy

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Editorial

FUTURE TECHNOLOGIES

1



Technology is the application of science. According to Collins dictionary, “technology refers to methods, systems, and devices which are the result of scientific knowledge being used for practical purposes”. According to Cambridge dictionary, “technology is the study and knowledge of the practical, especially industrial, use of scientific discovery”. Hence, we see that science and technology are intrinsically related. The word technology means the products resulting from such efforts including both tangible tools such as devices or machines and intangible ones such as software.

Civilisations around the world have been developed with the development of technologies. People have been greatly benefited from technologies. It has made our lives more comfortable. The world has now been divided into developed and developing countries. It is seen that the developed countries have improved technologies for their advantages. As seen from the definition of technology given above, industries have grown with the help of technology. Of course, technology is not always utilized for beneficial purposes and sometimes it is misused, for example in making nuclear weapons. Also technology has some side effects like environment pollution, climate change etc.

The world has witnessed a great technological leap in the last two decades. Innovations such as smartphones and tablets, 3D printing, artificial intelligence, block chain, cloud computing, robotics have been with us. These have changed our daily lives and the way we work. Further scientists say that these are just the beginning and more innovations in this field are coming in near future. We know that computer and internet have made a great impact on our life. Computer does a work in minutes, for which a person may take months to perform. But this has been found inadequate and we require faster computers, even faster than supercomputers. Scientists are now using quantum physics to develop quantum computer and quantum internet which would work with thousand times more speed compared to today’s computers.

Technology is rapidly improving, offering new innovations and revolutionary projects every year. Not only in the field of computing and information technology but also new innovations are also in the offing in the field of health, space, energy, biology, genetics etc. In the past what we had seen in science fictions are happening now and will continue to happen in future. At the beginning of this century, we used 2G technology in mobile phones, but now we are at 5G level which has made the mobile phone a mini computer.

Now scientists and engineers are working on some technologies which are hard to believe. Robots are being developed who can read our minds. Concept of smartwatches that are powered by sweat and bionic eyes are some examples of future technology. Self-driving cars have been manufactured on experimental basis and in a few years we can see lot of them roaming in our streets. Artificial intelligence is used in these cars and also in many other fields like agriculture, animal husbandry, health science and many more. Robotic surgery has already been started in some hospitals and clinics and in a few more years it will be more popular.

The world is passing through the environmental crisis of climate change and this is mostly due to combustion of fossil fuels in thermal power plants. Now technological innovation is going on to get clear, harmless power for nuclear fusion. The International Thermonuclear Experimental Reactor (ITER), a demonstrate project is under construction in France with the cooperation of many countries and it is hoped that it would be completed by 2030. Similarly, research is going on to get power from space by putting solar panels on satellites and transmitting the power to Earth in microwaves.

The American computer scientist and futurist Ray Kurzweil had said in 2005 that the next technological revolution would rest upon advances in genetics, nanotechnology and robotics, with robotics the most impactful of the three technologies. Within eighteen years, we have seen his prediction has become true. Robotics is now the area of active research in many laboratories. Genetic engineering has taken greater control over human biological nature. Scientists have now been able

producing artificial human embryo and editing the genome of a baby before birth to get a designer baby as per parent's desire.

In USA Hyper-loop company is working on a high-speed subway transportation system. The journey from New York to Washington D.C. is expected to take just 29 minutes instead of 2 hours and 56 minutes. This hyperfast trains could revolutionise not only local public transportation, but also international travel. Flying cars are another possibility.

Nano-robotics can be beneficial to health sector. It is a robot, of minimal size in the micro and nano-meter range, used in medicine. In the future, they will be developed to be used to place drugs in the right space in the eye or to destroy and detect cancer cells and toxins.

Technology is also revolutionizing food. As 3D printing technology advances, scientists are already experimenting with food printing. Meat is being grown in the laboratory. The company Ossiform has specialized in medical 3D printing, creating patient-specific replacements of different bones from tricalcium phosphate; a material with similar properties to human banks.

In this special issue of Science Horizon we had invited authors to contribute articles on "Future Technologies" and we have received many articles which include wireless energy transmission, e-vehicle, artificial intelligence, machine learning, energy storage technology, nuclear fusion, space technology, 3D printing etc. We are thankful to them for their cooperation. There are still some future technologies left out and we will try to accommodate them in our subsequent issues.

❁❁❁

Er. Mayadhar Swain
Editor

2

WIRELESS ENERGY TRANSMISSION



Dr. Sadasiva Biswal

Prelude

The world is now facing energy crisis due to enormous use of it by the vast population, which is also growing rapidly day-by-day. At present we are getting our usable energy from hydropower, windpower, solar power, magnetohydro-dynamic power, thermoelectric power and nuclear power etc. Now we are thinking up our future energy problems to crop up. Many scientists, technocrats, research institutions are seriously searching for the other possibilities to combat the future shortage of energy and the problems coming up thereby. Future technologies embrace nuclear fusion power, wireless energy transmission, energy from space, quantum computing, IOT, block chain, 3D printing, xeno-transplantation, virtual reality, genomics, design baby, gene technology, artificial intelligence, space colony, space ladder, asteroid mining, interstellar exploration, electric vehicle, battery technology, brain reading robot and many others to come up in future days. Such technologies are not only meant for meeting the energy demands of the people of the world, but also to explore various ways to design a lot of branches to play for the upliftment of human life and society as well. The genesis

and growth of new energy involve its transmission and distribution. Future technologies are not only limited to those cited above. Oceanography also needs developed technology to investigate and explore the enormous vast resources contained in the depth of the ocean. To generate energy from the tides is now forefront resource like solar energy, owing to the fact that 3/4th part of the earth is covered with water.

Here, in this paper, focus is given to deal with wireless energy transmission and the technology involved there in.

Electromagnetic Power Transfer

Wireless power transfer (WPT), Wireless power transmission, Wireless energy transmission (WET), or electromagnetic power transfer is the transmission of electrical energy without wires as a physical link. In a wireless power transmission system, an electrically powered transmitter device generates time-varying electromagnetic field that transmits power across space to a receiver device; the receiver device extracts power from the field and supplies it to an electrical load. The technology of wireless power transmission can eliminate the use of the

wires and batteries, thereby increasing the mobility, conveniences, and safety of an electronic device for all users. Wireless power transfer is useful to power electrical devices where interconnecting wires are inconvenient, hazardous, or are not possible.

Inductive charging pad for a smartphone is an example of near-field wireless transfer. When the phone is set on the pad, a coil in the pad creates a magnetic field which induces a current in another coil, in the phone, charging its battery.

Wireless power techniques mainly fall into two categories, viz. near field and far field. In near field or non-radiative techniques, power is transferred over short distances by magnetic fields using inductive coupling between coils of wire, or by electric fields using capacitive coupling between metal electrodes. Inductive coupling is the most widely used wireless technology; its applications include charging handheld devices like phones and electric toothbrushes, RFID tags, induction cooking, and wirelessly charging or continuous wireless power transfer in implantable medical devices like artificial cardiac pacemakers, or electric vehicles.

In far-field or radiative techniques, also called power beaming, power is transferred by

beams of electromagnetic radiation, like microwaves or laser beams. These techniques can transport energy to longer distances but must be aimed at the receiver. Proposed applications for this type include solar power satellites and wireless powered drone aircraft.

An important issue associated with all wireless power systems is limiting the exposure of people and other living beings to potentially injurious electromagnetic fields.

Coupling (electronics)

Wireless power transfer is a generic term for a number of different technologies for transmitting energy by means of electromagnetic fields. The technologies differ in the distance over which they can transfer power efficiently, whether the transmitter must be aimed (directed) at the

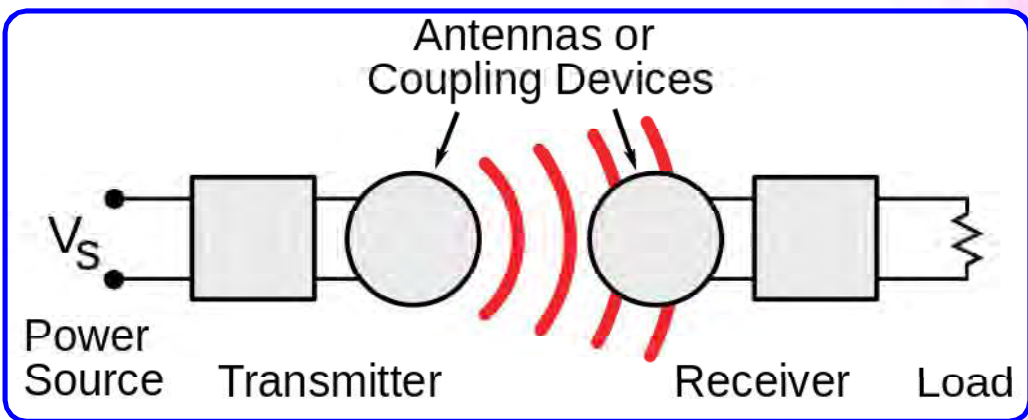


Fig.1 : Generic block diagram of a wireless power system

receiver, and in the type of electromagnetic energy they use; time varying electric fields, magnetic fields, radio waves, microwaves, infrared or visible light waves.

In general a wireless power system consists of a “transmitter” device connected to a source of power such as a mains power



line, which converts the power to a time-varying electromagnetic field, and one or more “receiver” devices which receive the power and convert it back to DC or AC electric current which is used by an electrical load. At the transmitter the input power is converted to an oscillating electromagnetic field by some type of “antenna” device. The word “antenna” is used loosely here; it may be a coil of wire which generates a magnetic field, a metal plate which generates an electric field, an antenna which radiates radio waves, or a laser which generates light. A similar antenna or coupling device at the receiver converts the oscillating fields to an electric current. An important parameter that determines the type of waves is the frequency, which determines the wavelength.

Wireless power uses the same fields and waves as wireless communication devices like radio, another familiar technology that involves electrical energy transmitted without wires by electromagnetic fields, used in cellphones, radio and television broadcasting, and WiFi. In radio communication, the goal is the transmission of information, so the amount of power reaching the receiver is not so important, as long as it is sufficient that the information can be received intelligibly. In wireless communication technologies only tiny amounts of power reach the receiver. In contrast, with wireless power transfer the amount of energy received is the important thing, so the efficiency (fraction of transmitted energy that is received) is the more significant parameter. For this reason, wireless power

technologies are likely to be more limited by distance than wireless communication technologies.

Wireless power transfer may be used to power up wireless information transmitters or receivers. This type of communication is known as wireless powered communication (WPC). When the harvested power is used to supply the power of wireless information transmitters, the network is known as Simultaneous Wireless Information and Power transfer (SWIPT); whereas when it is used to supply the power of wireless information receivers, it is known as a Wireless Powered Communication Network (WPCN).

These are the different wireless power technologies, which are in use, namely;

- i. Technology
- ii. Range
- iii. Directivity
- iv. Frequency
- v. Antenna devices

vi. Current and/or possible future applications, that embrace Electric tooth brush and razor battery charging, induction stove tops and industrial heaters, charging portable devices (Qi), biomedical implants, electric vehicles, powering buses, trains, MAGLEV, RFID, smartcards charging portable devices, power routing in large-scale integrated circuits, smartcards biomedical implants are also being investigated. Solar power satellite, powering drone aircraft, charging wireless devices, charging portable devices, powering drone aircraft, powering space elevator climbers

adhere to the frequency \geq THz, lasers, photocells, lenses, light waves, long distance communication and high directivity.

Epilogue

The basic procedures of wireless energy transmission are modulation and demodulation. Since the signal (audible sound) has frequency 20 Hz to 20 kHz and velocity in air at NTP is nearly 331 m/s and at 20 degree Celsius is 343 m/s, the signal cannot travel to far of places. So, a carrier wave is needed to drag the signal to large distances. The wave which carries the signal to far of places is called carrier wave. Radio wave is the signal + carrier wave. The radio wave travels with the velocity of light ($c = 3 \times 10^8$ m/s). The carrier wave has a large frequency in comparison with the signal. The carrier wave is obtained from an oscillator.

Modulation is the process of mixing signal with the carrier and the resultant wave so obtained is known as modulated wave or radio wave.

For radio wave broadcasting we need (i) Transmitter and (ii) Receiver.

A transmitter contains the following parts;

- a) Microphone b) Audio amplifier
- c) Oscillator d) Modulator
- e) Transmitting antenna

Radio wave is transmitted from the transmitting antenna and moves in space and received by the receiving antenna of the receiver. The receiver receives the radio waves

through its receiving antenna. Here in the receiver, signal is separated from the carrier by the process of demodulation. Then the signal is fed to the amplifier and the amplified signal is fed to the speaker that produces the sound waves in original.

In other words, the process of changing some characteristic (i.e. amplitude, frequency or phase) of a carrier wave in accordance with the intensity of the signal is known as modulation. Therefore, three types of modulation are there, namely, amplitude modulation, frequency modulation and phase modulation.

The process of recovering the audio signal from the modulated wave is known as demodulation or detection.

Demodulation is barely needed, owing to the fact that the modulated wave or radio wave is transmitted from the transmitter by the transmitting antenna. In the receiver side, if the modulated wave after amplification is directly fed to the speaker, no sound will be heard.

From the above discussion, it follows that the audio signal must be separated from the carrier at a suitable stage in the receiver. The received audio signal is then amplified and fed to the speaker for conversion into sound. The circuit which demodulates radio wave is called detector. This detector circuit performs the following functions.

- i) It rectifies the modulated wave, that means the $-ve$ half cycles are eliminated.
- ii) It separates the audio signal from the carrier.



The rectified modulated wave contains the audio signal and the carrier. The audio signal is separated from the carrier by the filter circuit of the detector which removes the carrier frequency and allows the audio signal to go to the speaker. Obviously, this is the principle of radio wave transmission or wireless communication.

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Retired Principal & Professor of Physics,
506, G.A. Colony, Bharatpur,
Bhubaneswar-751029
Mob. 9437467474

Power from Space

The concept of harnessing solar energy from space, known as space-based solar power (SBSP), is inching closer to becoming a viable reality. While the idea has been around since the late 1960s, challenges related to cost and technology have hindered its progress. However, recent advancements and evolving concepts suggest that SBSP could play a significant role in the transition to green energy.

On the Earth solar power generation have some limitations, as they rely on land availability and are impacted by varying light and weather conditions. Further, it can be generated only on day-time. In contrast, SBSP using satellites in geostationary orbit (GEO) presents a promising solution. Satellites in GEO are exposed to the Sun for over 99% of the year, enabling them to produce continuous solar energy.

Wireless power transmission using microwaves is being considered to transmit energy collected in space to the Earth. This method minimizes energy loss through the atmosphere and allows for efficient energy transfer even in cloudy conditions. The microwaves are focused on a ground station equipped with antennas that convert them back into electricity. Various SBSP designs have been proposed over the years.

Despite the potential, challenges remain. The main hurdle is the substantial mass and associated launch costs of SBSP satellites. Companies like SpaceX and Blue Origin are developing heavy-lift launch vehicles to reduce costs through reusability. China, Japan and USA are working on this and it is hoped to get electricity from space by 2050.

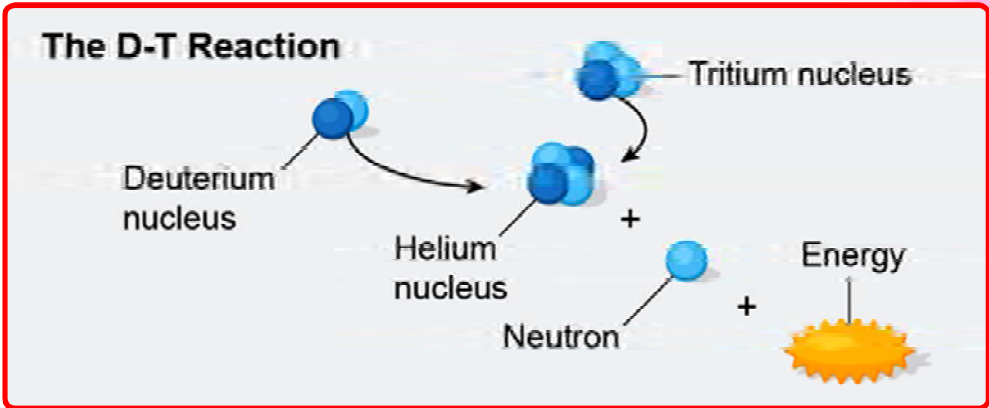
- Er Mayadhar Swain

NUCLEAR FUSION ENERGY – HOW CLOSE TO REALITY?

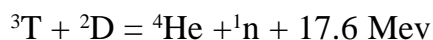
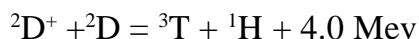
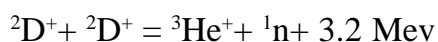
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Prof. S.K. Mohapatra

In late 1945 Enrico Fermi envisioned the potential of fusion of lighter nuclei, as isotopes of hydrogen, deuterium and tritium in particular, as an in-exhaustible source of energy on the basis of the binding energies of the reacting nuclei and the product nuclei and neutrons formed in the process. It would be not only a source of zero carbon energy but also free from the dangerous radioactive waste associated with the fission processes. The



three reactions, which are of importance are-



The first two reactions take place almost at the same rate at a given temperature. The last reaction is about hundred times faster at equivalent concentration at the same temperature. Therefore, it has attracted much attention of all scientists.

The basic fuel material for the fusion is readily available and can be extracted at very

low cost unlike the fuels for a fission reaction. Amounts of deuterium present in natural water is sufficient to provide energy requirement of the world for several years. Deuterium present in one gallon of water has

energy equivalent same as that is obtainable from the combustion of 300 gallons of gasoline. More than 10^{20} gallons of water present in the oceans. But the fusion processes have the serious problems of ionisation, confinement of the ions and electrons formed (plasma) and fusion of the nuclei at reasonable rate to be a practical source.

Production of Plasma

The energy required to bring about fusion of isotopes of hydrogen, on the average, is about 0.1 Mev. Energy of this magnitude

would be possible if the temperature as high as 1000 million degrees kelvin can be created in the container. Acceleration of nuclei will not achieve this simply because of strong electrostatic repulsions. Fission induced fusion would be uncontrolled and would result in explosion. Use of intense laser blasts (1000 beams per day) would produce practical amounts of heat and pressure for fusion, but again such blasts can take place only once in a span of several hours as the equipment need time to cool. Further, it is important to maintain the D-D or the D-T systems at temperatures, required for the fusion at which the energy released is more than radiation loss to be sustainable. Temperatures in excess of 5 keV (60 million degrees Kelvin) has been attained in plasma with particle densities greater than 10^{16} with a mixture of deuterium and tritium as the fuel. But the confinement time have been a few microseconds, compared with the milliseconds that are probably the minimum necessary for a practical fusion system.

Confinement of Hot Plasma

No solid material, even extremely heat resistant metals as tungsten can withstand such extreme temperature conditions. The process requires exquisite control. The furiously hot plasma would be turbulent and would produce beams of high energy neutrons that would bore holes in the reaction chamber. Therefore, the charged

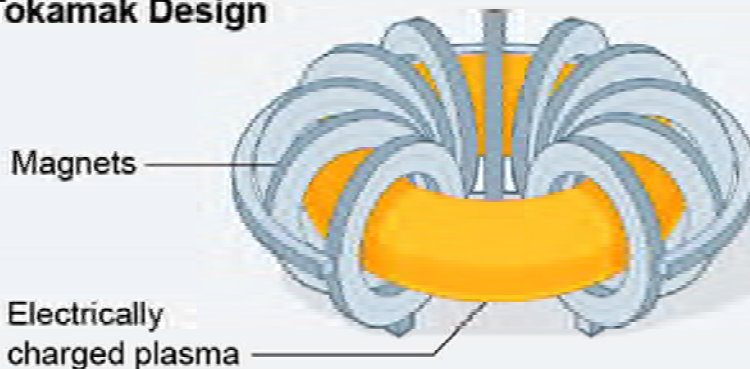
particles produced must be confined in a small volume in the core and kept away from the walls of the container to avoid transfer of energy that will cause vaporisation of the metal and add impurities of high atomic number resulting in cooling and loss of energy.

One way would be to pass a very strong electric current (millions of amperes) through the deuterium or the deuterium tritium mixture in the shape of a toroidal or doughnut shaped porous tube (called a tokamak) at low pressure. The current heats up the gas and ionises it, converting it into plasma and at the same time it produces the magnetic field with the lines of force encircling the plasma. The pressure of the field compresses the plasma into an arrow region of the tube.

In 1950 astrophysicist Lyman Spitzer suggested plasma might be confined more effectively in a tokamak with a twisted tunnel or in an oval shaped tube by a combination of magnetic fields employing a sets of two coils, one set generating an axial field and the other in helical mode to produce the twist.

Another approach uses an axial field by

Basic Tokamak Design



winding a coil of wire around the torus and passing an electrical current. but such a field would not be uniform as the magnetic field would be stronger at the inner perimeter than at the outer perimeter. Many other systems such as magnetic mirror, magnetic well to confine have been applied but have not been very encouraging.

Pilot Projects Started

Most developed Nations from west to east have either individually or jointly taken up pilot projects. The largest fusion project International Thermonuclear Experimental Reactor, (ITER) in France supported by European Union, U.K, China, India, South Korea began in 2007. It was hoped the reactor to generate continuous energy about 500 MW by 2020. But it has suffered setbacks for engineering problems.

Of late, there has been increasing interest in smaller devices with spherical shape like an apple. One such, device called STEP(spherical tokamak for energy production)has proved successful and has encouraged UKAEA (U.K Atomic Energy Authority) to develop the pilot plant for commercial purpose.

Another prototype device called SPARC by CFS (plasma science and fusion center), a mid-sized tokamak is being developed using high temperature superconducting magnets, that does create a very intense magnetic field to confine plasma.

National Ignition Facility (NIF) has carried out experiment with tiny pallet shaped targets having the fuel mixture and intense

laser beam focused on it. Energy releases in pulses and the pallet has to be changed constantly ten times a second to be practical.

On 5th December Mathew Spark working at Lawrence laboratory (National Ignition Facility), reported a breakthrough in nuclear fusion. He used a small diamond capsule with two frozen hydrogen atoms inside and laser shuts of 2.05 mega joules, could produce 3.15 mega-joules of energy released that can boil 10 kettles of water. A power plant would need to produce 30-100 times more energy.

Future of Fusion Power

Physicists have been studying the fusion power since 1950s. Most experts believe that generation of large-scale energy even before 2060 is unlikely. However, it will be the best option to meet the energy demand of the world by 2050 and scientists and technocrats believe it is not impossible. There is hope, says Prof. Ian Chapman, chief executive of U.K. atomic energy authority. The problems of confining a high temperature, high density plasma, and control over an appreciable time will be achieved.

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Prof. S. K. Mohapatra
1595 / 96 Bhoi Nagar, Unit – IX
Bhubaneswar,
Mob. - 8984592003



HELIUM 3 FROM MOON: THE FUTURE SOURCE OF ENERGY

4



¹Dr. Ramesh Chandra Parida

²Dr. Sunita Chand

Since 1969, when the first manned-moon mission Apollo-11, returned to the earth with samples of lunar rock and soil, the idea of establishing a human base on it has been growing in the minds of the scientists, the planners and even, the common people, all alike, even after the USA called off such projects in December 1972, the last being the Apollo-17. Therefore, after a long break, in recent years, the efforts have re-emerged in a big way and the four countries, Russia, the USA, China and India, who have succeeded in landing their missions on the moon as well as Japan have begun to undertake various programmes to explore and possibly exploit resources that can be found in the lunar surface. The successes of the Chandrayans of India and the Chang' es of China have set a stage for a "cold war" of new kind among them. Of all the sources for which the moon can possibly be exploited, helium-3 (^3He) has taken the forefront as a nearly unending resource for energy production, which the nuclear scientists visualise as the cleanest fuel for the future fusion reactors.

Helium is the second member in the Periodic Table of elements made up of 2 neutrons and 2 protons and therefore, has an

atomic mass 4 (represented by ^4He). But it also has a minor stable isotope having 2 protons and 1 neutron. Therefore, its atomic mass is 3. It is helium-3 represented by ^3He . This isotope was discovered in 1934 by the Australian nuclear physicist Mark Oliphant. Since it is non-radioactive, it is hoped to be an ideal fuel for the operation of fusion reactors when used along with deuterium (heavier isotope of hydrogen having atomic mass 2 and represented by ^2D) with the advantage of not producing neutron.

Currently all the nuclear power plants are using fission reactors, in which uranium nuclei are split apart to release energy. However, such processes produce radioactive wastes, which are highly hazardous to the environment and therefore need to be safely stored indefinitely. It is a cumbersome process. On the other hand, there is nuclear fusion, effectively the same energy source that fuels the sun and the other stars but produces no radioactivity and nuclear waste. Therefore, at present, it has attracted the attention of the nuclear scientists and very soon it is likely to replace the fission reactors for the production of nuclear energy.

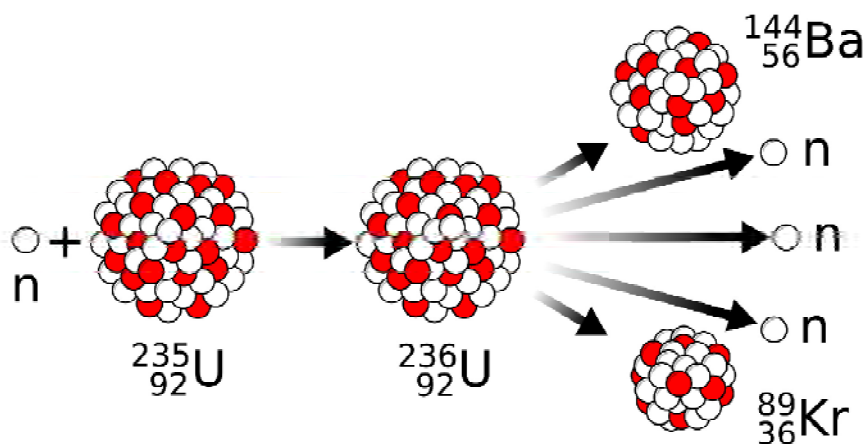


Fig.1: Nuclear Fission Reaction

In the present day fusion reaction which are still in experimental stage usually deuterium (^2D) and tritium (^3T) isotopes of hydrogen are used as the fuel. It requires a temperature of about 150 million degree Kelvin for the nuclei to fuse and the by-products generated contain very energetic neutrons (along with helium), which can continuously bombard the surrounding materials and damage them. To overcome it, the most advanced fusion devices that are on trial are inertia confinement fusion such as the National Ignition Facility and magnetic confinement fusion such as, the International Thermonuclear Experiment Reactor (ITER). In the case of the former, yet there is no solid roadmap to power generation, but in the case of the latter, commercial power generation may take a few decades, 2030 to 2050.

nuclear fusion reactions, the fusion of helium-3 atoms releases large amount of energy without causing the surrounding material to become radioactive. On the other hand, such fusions also need much more higher temperature and the reactors are to be larger needing more investments. However, with the development of the technology, these barriers may be overcome. Besides, ^3He also can have many other important uses such as various

One of the advantages of using ^3He (a non-radioactive isotope of helium) as the fuel in the fusion reactors is that the reaction taking place in those do not release neutrons but protons, which can be easily contained, thanks to their positive charge. Again unlike most

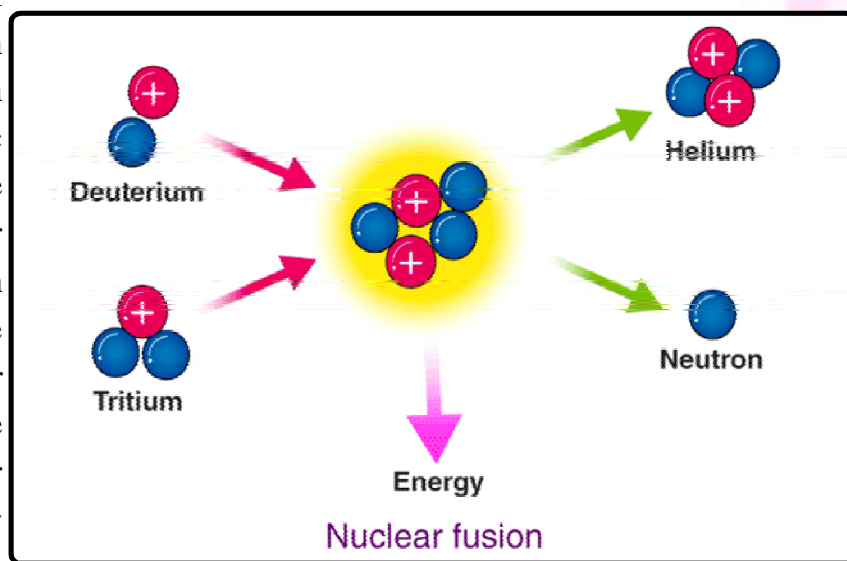


Fig.2: Nuclear Fusion Reaction releasing Neutron

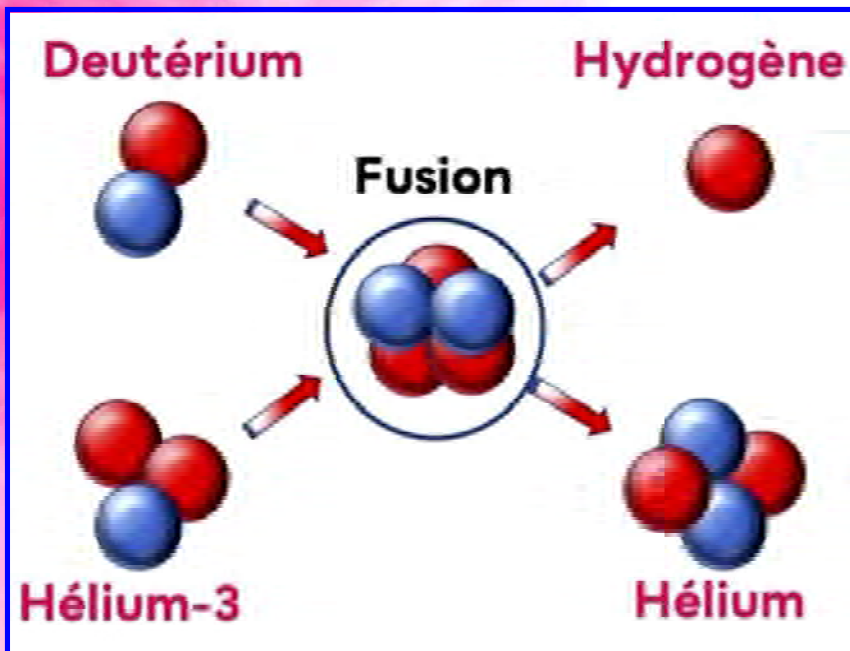


Fig.3: Nuclear Fusion Reaction with Helium-3 releasing proton (hydrogen)

took a concrete shape in 1986 when a number of scientists starting with Gerald Kulcinski of the University of Wisconsin-Madison proposed to explore the moon, mine the lunar neolith and use it for fusion. Prior to it, a geologist of the Apollo programme had also made repeated argument for helium-3 mining from moon. However, the race for it gathered momentum after the post 2003 moon mission of

China. The other moon scientific experiments like spin echo, neutron detection, cryogenics, medical imaging and radio energy absorber for tokomak plasma experiments.

conquering nations, Russia, the US and India which were giving importance for looking for water, oxygen and possibility of life on it gradually joined the race particularly after the lander of its Chang'e mission landed on the lunar surface in 2013 and explored it.

Natural abundance of helium-3 is very limited as compared to deuterium and tritium. It is only 0.000137% on the surface of the Earth. However, some helium-3 can be produced from the radioactive decay of tritium, which is not enough. Therefore, now there is a mad rush from various countries to obtain it from the moon, where there is about 1.1 million tons of helium-3 with an average concentration of 4 parts per billion in the neolith layer and as high as 10 ppb at certain places. Accordingly to another calculation, the concentration of helium-3 may vary from 1.4 to 15 ppb in the sunlit areas of the moon while it may be 50 ppb in its permanently shadowed regions.

China sent its first probe into the orbit around the moon in 2007. Since then the Chang'e 4 (2018) and Chang'e 5 (2020) have made significant progress in the knowledge and study of data on topography and composition of the lunar soil. One of the objectives of these trips is to determine the exact amount of helium-3 present in it. Now, the Beijing Research Institute of Uranium Geology is measuring the content of it in the lunar soil, evaluating its extraction parameters and studying the ground fixation of this isotope. The cosmochemist and geochemist Ouyang Ziyuan from the Chinese Academy of Sciences, who is now in charge of the China Lunar

The idea of mining the lunar helium-3

Exploration Programme has already stated on many occasions that one of the main goals of their programs would be the mining of helium-3. According to some sources, one of the primary objectives of the Indian Space Research Organisation's first lunar probe Chandrayan-1, launched in 22 October, 2008 was also to map the moon's surface for helium-3 containing minerals.

In fact, one of the China's moon missions is set to have collected sample of the crystalline helium-3 called Changesite named after their moon God Chang'e. The extreme cold in the moon's polar region and on its dark side has caused these particles to crystallise. It is also in the news that China is planning to set up a helium 3 fusion factory in the Earth's higher orbits and then beam energy into their receiver systems built at Chegole. About 25 tons of solidified helium-3 that a rocket payload can carry may meet the energy needs of a country like China for one year and a country like India for four years. Therefore, in a near future a mad rush for mining and

transporting helium-3 from the moon by the nations who have already reached there is on the cards and many others like Japan, the European Union and some Gulf Countries, are likely to follow them. Even certain private companies such as Shackleton Energy Company and Commonwealth Fusion Systems of the US, RKK Energies of Russia have come forward with their plans to take part in such efforts. Even there is a talk about exploiting the atmosphere of the Jupiter for helium-3. If these efforts succeed and it can be used as a viable nuclear fuel in future, it is expected that the moon surface can provide enough of it to meet the energy requirements of the world for more than 10,000 years.



¹Retd. Professor, OUAT,
124/2445, Khandagiri Vihar, Bhubaneswar (Odisha)
Mobile: 9937985767

²Professor, Centre for Data Science,
Institute of Technical Education and Research (ITER),
Siksha 'O' Anusandhan (Deemed to be University),
Jagamara, Bhubaneswar, (Odisha)
Mobile: 9437500971

From Where Does Helium-3 Come to Moon

It is believed that an astronomical body (astronomers now call it Theia) collided with Earth and a portion of Earth's mass was separated from it to form the Moon. Now it has been estimated that a total of 1.1 million metric tons of He-3 have been deposited in Moon's soil. In contrast, Earth is estimated to have only 300 kg of He-3. What is the reason? The Sun produces vast quantities of Helium by fusing hydrogen atoms together. This fusion reaction provides energy to the Sun. A small amount of He-3 is also produced. Both types of helium travel toward Earth as part of the solar wind. He-3 never makes it to Earth because the Earth's magnetic field pushes it away. On the other hand, Moon has no significant amount of magnetic field and He-3 gets accumulated in the debris layer of Moon's dust and rock. The little amount of He-3 in the Earth has come out as a by-product of the maintenance of nuclear weapons.

- Editor

E-VEHICLE: FUTURE TRANSPORTATION TECHNOLOGY

5



Dr. Bijay Ketan Patnaik

An EV is shortened acronym for an electric vehicle which uses one or more electric motors for propulsion. EV is defined as a vehicle that can be powered by an electric motor that draws electricity from a battery which is capable of being charged from an external source and also includes a vehicle that draws electricity from a battery and also by an internal combustion engine. The second type is called as plug-in hybrid vehicle.

Origin of Idea

Early electric vehicles first came into existence in the late 19th Century, when the second Industrial Revolution brought electricity. Using electricity was among the preferred methods of motor vehicle propulsion as it provides a level of quietness, comfort and ease of operation that could not be achieved by the gasoline engine cars of the time. During the year 1902, Studebaker Automobile Company of America first started production of e-vehicle. But since the fossil fuel driven vehicles/ cars produced by Ford Company were much cheaper and having wide range; the popularity of e-vehicle waned and their demand plummeted. In the late 1960s and early 1970s, concerns about the pollution and the more

important, the OPEC oil embargo, kindled interest in e-cars. This got further impetus in California's Zero Emission Vehicle mandate that demanded two percent of California's vehicle to be having zero emission by 1998 and 10 percent by 2003. But in general, the mandate for mass production of e-vehicle could not pick up momentum due to technical and cost barriers. Sales plummeted and global car makers such as Toyota rolled back their plans. Such type of situation continued for around 100 years till the later part of 20th Century.

Advantages and Disadvantages of e-vehicle

Any type of vehicle to be acceptable to consumers and to conquer market depends in its comparative advantages and disadvantages. E vehicles are:

- i) Fuel efficient: Technically the conversion of electrical energy into motion power is more efficient than burning fuel in an internal combustion engine. The estimated fuel efficiency of e-vehicles is three times higher than the commercial car.
- ii) Cost effective: Electric vehicles have

low running costs as they have less moving parts for maintaining; so low maintenance cost. Moreover, as electricity costs significantly less than oil, the operating cost per kilometre falls to a fraction of that in a petrol car.

- iii) Environment friendly: Since they use little or no fossil fuel there is little or no green house gas emission. According to estimates made by the Argonne National Laboratory in USA, electric vehicles would reduce GHG emission by 26% over gasoline powered vehicles.
- iv) Easy to drive, quiet and less noisy.
- v) Convenience of charging at home.
- vi) Spacious cabin and more storage space.
- vii) Lots of tax and financial benefits, because of promotion activities by different Governments.

Disadvantages are also quite a few.

- i) Exorbitant initial cost. A general consumer cannot afford to straight away purchase an electric vehicle.
- ii) Limited range of models is available in the market, which prevents buyers not being able to exercise their choice.
- iii) Lack of charging infrastructure in highways, towns and rural areas have significantly slowed down the commercialisation of e-vehicle.
- iv) Slow investment in improving the technology is another obstacle in proliferation of e-vehicles.
- v) The battery is a major havoc of the cost

of e-vehicles. It costs nearly 30 percent of an e-bike's price. And it has to be replaced every two to three years. Currently the automotive battery market is dominated by Nickel-metal Hybrid or lead acid batteries; but experts predict that lithium-ion/lithium sulphur batteries would capture the market in near future.

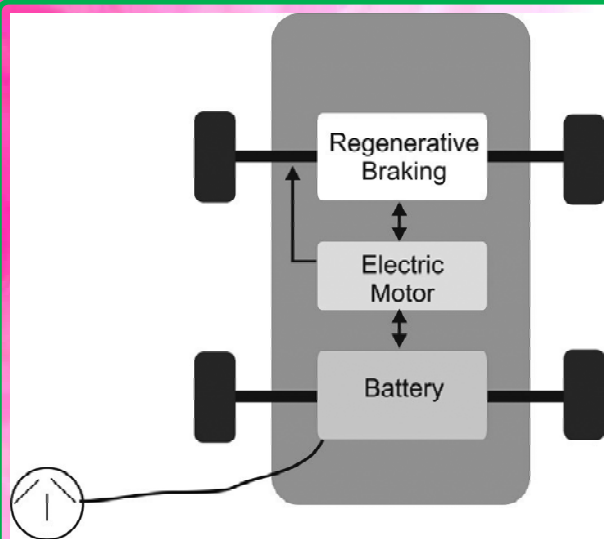
Types of e-vehicles

There are 4 types of electric vehicles presently in use. These are:

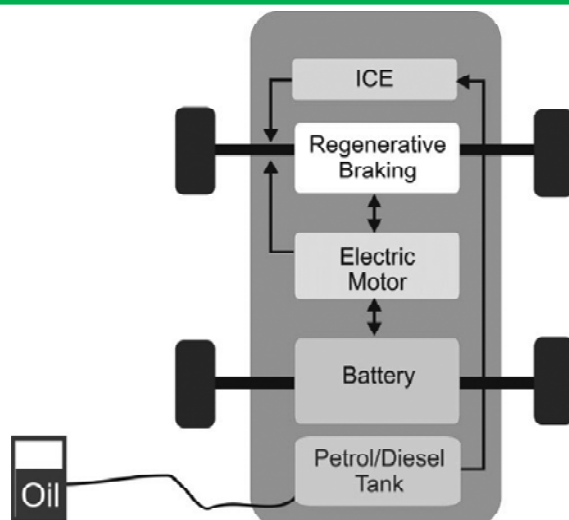
- a) Battery Electric Vehicle (BEV)
- b) Hybrid Electric Vehicle (HEV)
- c) Plug-in Hybrid Electric Vehicle (PHEV)
- d) Fuel Cell Electric Vehicle (FCEV)

BEV or Battery Electric Vehicles are fully powered by electricity. These are more efficient compared to Hybrid and Plug-in Hybrid vehicles. In this type of e-vehicle an electric motor is there in place of internal combustion engine and there is a battery pack in place of oil tank, which can be charged from an external electric point. The stored electricity from the battery rotates the motor and ultimately the tyres of the vehicle move.

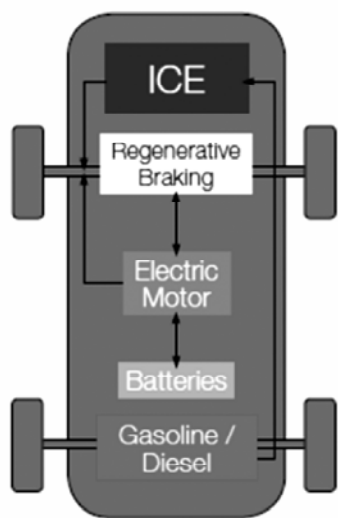
Hybrid Electric Vehicle (HEV) is the vehicle that uses both the internal combustion (usually) petrol engine and the battery power motor. As these vehicles can move or run both by electricity, as well as fossil fuel, there are battery pack, a motor, internal combustion engine and a fuel tank. The petrol engine is used both to drive and charge the battery when the battery is empty. These vehicles are not as efficient as fully electric



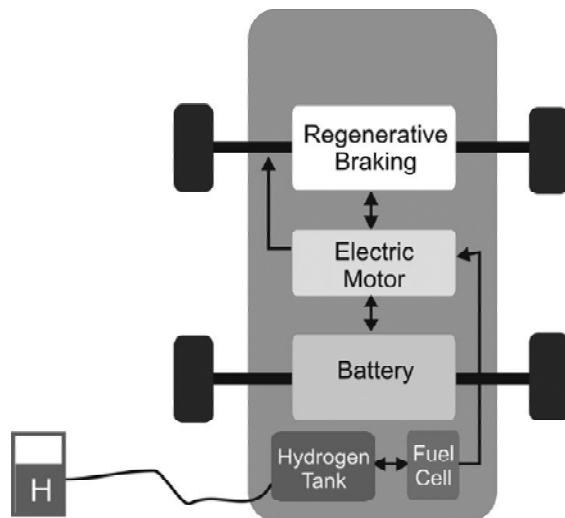
Architectural-diagram of BEV



Architectural-diagram of HEV



Architectural-diagram of PHEV



Architectural-diagram of FCEV

or plug-in hybrid vehicles.

Plug-in-Hybrid Vehicle (PHEV) uses both an internal combustion engine and a battery charged from an external socket i.e. a plug. This means the vehicle's battery can be charged with electricity, rather than engine. PHEVs are more efficient than HEVs but less efficient than BEVs.

In Fuel Cell Electric Vehicle (FCEV), electric energy is produced from chemical

energy. The Fuel Cell that is used in this type of vehicle draws oxygen from air and use compressed hydrogen gas that produces chemical energy. Fuel cell converts this chemical energy to electrical energy. The use of this type of e-vehicles is mostly limited.

World Scenario on Production of e-vehicles

Though the first mass production of electric vehicles appeared in America in the

early 1900s, but due to its exorbitant cost, lack of electricity grids and the limitation of storage batteries at that time, electric cars didn't gain much popularity, for over a century. However, in the meantime, electric trains gained immense popularity due to their economics and achievable speeds. By the 20th century, electric rail transport became common place due to advances in the development of electric locomotives.

In the early 21st century, many countries around the world have announced aggressive electrification targets upto 100 percent by 2020-50, to fulfil their climatic commitment. The Copenhagen world climate summit, 2009, was conducted in the midst of a severe observable climatic change brought on by human-made greenhouse gas emissions. During the summit, more than 70 countries developed plans to eventually reach net zero. For many countries, their markets are adopting targeted Zero Emission Vehicles (ZEV) regulations to accelerate the rate of transformation. Ten states in the US, China, and few provinces in Canada, by then already adopted ZEV mandate. California, one of the states of US has followed a ZEV mandate since 1990. ZEV mandate requires manufacturers to sell a minimum number of zero emission vehicle-these include fully electric vehicles to plug-in hybrid vehicles as a share of their overall sales in the market. The European Union has also adopted ZEV regulations though they are voluntary and the manufacturers are free to decide their target.

Original equipment manufacturers say

that electric vehicle growth will primarily be driven by the two and three wheeler segments, followed by electric bus and that it will take some time for EV sales to rise in car segment. Shifting of large auto-markets, particularly the light-duty-vehicle (LDV) segment, towards ZEV in the US, China and the European Union has resulted a big change in the global auto market, since the increasing number of large car manufacturers have started setting their own voluntary targets to electrify all or a portion of their fleets over the next decade. It is important to mention that the US, China, European Union along with India, Japan and Korea account for 80 percent of the total global light-duty-vehicle sale.

Indian Scenario

Like other nations, India is banking on electrification for decarbonising its transport sectors as one of the key levers to fulfil its global commitment to reduce one billion tonne of carbon and to cut the emission intensity of the economy by 45 percent by 2030. This pledge was given by India, when it signed the 26th Conference of Parties (COP26) to the United Nations Framework Convention on Climate Change held at Glasgow in 2021. In this pledge two and three wheelers were mentioned as important segments that would lead to transition to zero-emission vehicles since in our country two and three wheelers constitute 80 percent of new vehicles registration every year.

In 1996, the first electric vehicle in India was three wheeler manufactured by Scooter's India Pvt. Ltd. In 2000, BHEL (Bharat Heavy Electricals Ltd.) developed an eighteen

seater electric bus which was popular too. REVA, India's first zero polluting electric vehicle for city mobility was commercialised in June, 2001. Mahindra's REVAi was the first electric car in India launched in May, 2010. Over the past couple of years, the Government of India has taken several steps towards faster adoption of electric vehicle. About 21 states of the country have notified or drafted their own EV policies, with a large focus on two or three wheelers. In addition, under the National Clean Air Program (NCAP) 132 cities have included electrification of two and three wheelers in their Clean Air Action Plan.

The other steps include incentive based strategies both for producers and consumers. One is production linked incentive to users of electric vehicle. Purchase incentive includes subsidy to the cost of vehicle, exempting registration fee full or half or providing free insurance, reducing interest rate for availing loan to purchase two, three or four wheeler e-vehicle etc. Currently, at the National level, there are two incentive programmes for adoption of EVs. One is Faster Adoption of

Hybrid and Electric Vehicles created with a corpus of Rs.10,000/- Crore to support about 1.56 million vehicles, including 1 million two wheelers, 0.5 million three wheelers, 55 thousand passenger cars and 7,000 electric buses.

All such incentivised steps taken either by Central or State Governments had a positive impact on production and sale of e-vehicles. Compared to gasoline driven cars, where carbon footprint is 360 grams of CO₂ per mile; for battery driven e-vehicle it is less than 200 grams of CO₂ per mile. If we could generate electricity from solar power or nuclear power than thermal power, then the carbon footprint could be further reduced. Following Paris Climate Agreement, if the greenhouse gas emission is to be drastically reduced by 2030, then bringing down CO₂ emission from transport section, by switching over to e-vehicle is the one and immediate option available to mankind.

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Former PCCF (Wildlife), Odisha
Mob. 9437000904

Vehicle-to-Vehicle (V2V) Communication

Imagine if vehicles could "talk" to one another while out on the road to avoid accidents, coordinate lane changes, or manage traffic jams. That is what researchers believe that vehicle-to-vehicle communication would allow. Vehicles would be able to use numerous sensors and wireless signals in order to analyze and detect their surroundings, and instantaneously communicate with surrounding vehicles. The result would be a much safer and efficient method of travel. In fact, a study by the National Highway Traffic Safety Administration of USA found that V2V communication has the potential to decrease vehicle crashes by as much as 79%. While this technology has been talked about for years, with the continued push towards autonomous vehicles, it's looking more and more like something that we will end up seeing at some point in the future.

-Editor

MINING THE ASTEROID: A DREAM NOT FAR FROM BEING REALIZED

6



Nikunja Bihari Sahu

In a landmark development on September 24, 2023, a sample weighing nearly 250g collected by a spacecraft of NASA named OSIREX REx from a small asteroid Bennu of our Asteroid Belt was successfully delivered to our Earth for research and study by the scientists. In a novel exercise, the spacecraft did not land on the Earth, but rather released a capsule from nearly 1,00,000 km altitude which entered the Earth's atmosphere and parachuted with reduced velocity to safely land with the sample in the Utah desert. The spacecraft, without landing on the Earth, headed for another asteroid in our Asteroid belt for further mission. Although the sample collected was miniscule in quantity and was only meant for scientific study, the mission aroused the hope of mining precious metals like Gold and Platinum from the asteroids and ferrying them safely to the Earth for the benefit of entire humanity.

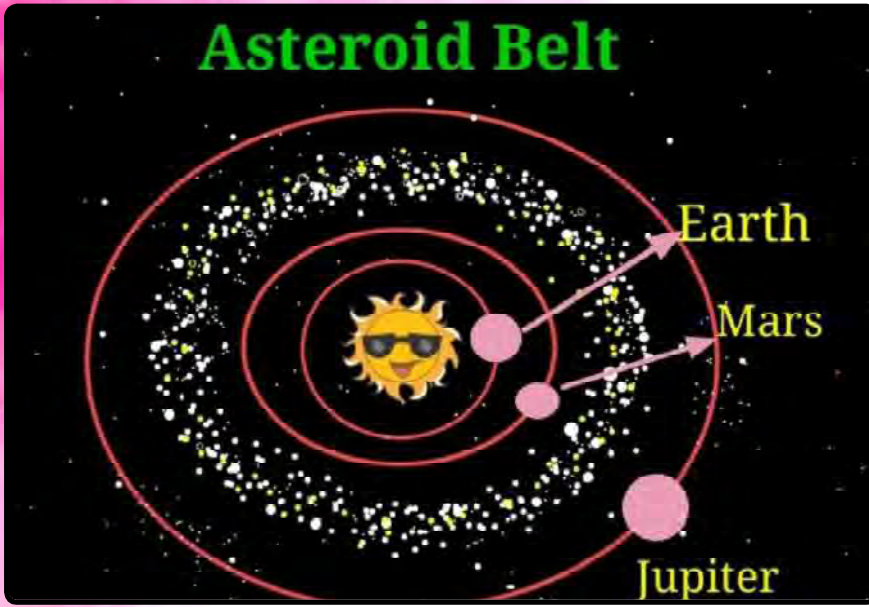
In fact, OSIREX Rex was not the only mission to have collected the asteroid sample, but in the past the Japanese Space Agency JAXA has also succeeded in returning asteroid samples to Earth through its Hayabusa missions. However, these were research missions and commercial missions to

asteroids are a long way through considering the potential challenges of the task that include the high cost of spaceflight, unreliable identification of target asteroids and the challenges of extracting usable material in a space environment and delivering successfully to the Earth.

What are Asteroids?

An asteroid is a minor planet that orbits within our inner Solar System. These are rocky, metallic or icy bodies with no atmosphere and very little gravity. Sizes and shapes of asteroids vary significantly, ranging from 1-meter rocks to a dwarf planet almost 1000 km in diameter. Of the roughly 1 million known asteroids, the greatest number are located between the orbits of Mars and Jupiter, approximately within 2 to 4 AU distance from the Sun, in the main Asteroid Belt. The size of asteroids varies greatly; the largest asteroid Ceres is almost 1000 km across and qualifies as a Dwarf planet. The total mass of all the asteroids combined is only 3% that of the Earth's Moon. The majority of main belt asteroids follow slightly elliptical stable orbits revolving in the same direction as the Earth and taking from 3 to 6 years to complete a full circuit of the Sun. The asteroid 4- Vesta, due to its high reflective surface, is

Asteroid Belt



as Gold, Platinum, and Rhodium. A small 10m size S-type asteroid could contain as much as 650,000 kg of metal with 50 kg in the form of rare metals like Platinum and Gold.

The M-type or Metal asteroids are very interesting because some of them are thought to be the remaining cores of early planets that never ended up forming completely. They have high

concentrations of metals usually Nickel and Iron. This is the type of asteroid that scientists often refer to when they talk about asteroid mining and harnessing of space resources.

M-type asteroids are believed to have been formed close to the Sun and they would have been exposed to high temperatures in their early days. Some of them might have even had iron volcanoes at some point of time. These asteroids are also the source of the metallic meteorites that sometimes reach our Earth; these meteorites are pieces that fell off after a collision of an M-type asteroid with another object.

There are mainly three types of asteroids, namely C-type, S-type and M-type:

C-type or Carbonaceous asteroids are the most common variety, forming around 75% of known asteroids. They are volatile-rich and distinguished by a very low albedo because their composition includes a large amount of carbon, in addition to rocks and minerals. They have an average density of about 1.7 g/cm^3 . The C-type asteroids have a high abundance of water. C-type asteroids also have high amounts of organic carbon, phosphorus, and other key ingredients for fertilizer which could be used to grow plants in a space environment.

The S-type or Silicate asteroids are mostly stony and made out of Iron silicates or Magnesium silicates. S-type asteroids carry little water but are more attractive because they contain numerous metals including Nickel, Cobalt, and more valuable metals, such

A class of easily retrievable objects (EROs) was identified by a group of researchers in 2013. Twelve asteroids made up the initially identified group, all of which could be potentially mined with present-day rocket technology. Of the 9,000 asteroids searched in the Near Earth Objects (NEO) database, these twelve could all be brought into an Earth-accessible orbit by

changing their velocities by less than 500 meters per second (1,800 km/h; 1,100 mph). The dozen asteroids range in size from 2 to 20 meters.

History of Asteroid Mining

Before 1970, asteroid mining existed largely within the domain of science fiction. Stories such as 'Worlds of If', 'Scavengers in Space' and 'Miners in the Sky' described the conceived dangers, motives, and experiences of miners engaged in mining the asteroids. Although scientists envisioned about the benefits that could be gained from asteroid mining, they lacked the necessary technology to seriously pursue the idea. However, with man first landing on the Moon in 1969 and successfully bringing back lunar rocks to the Earth, the ambition of asteroid mining was again aroused. Subsequently, some scientists moved away from the asteroid craze and rather thought of targeting the nearby celestial objects like the Moon, Mars and its small satellites namely Deimos and Phobos.

Composition of Asteroids and Why These are of Interest to Us

Although asteroids and Earth accreted from the same starting materials, Earth's relatively stronger gravity pulled all heavy siderophilic (Iron-loving) elements into its core during its molten youth stage more than 4 billion years ago. This left the crust depleted of such valuable elements until a rain of asteroid impacts re-infused the depleted crust with gold, cobalt, iron, manganese, molybdenum, nickel, osmium, palladium, platinum,

rhodium, rhodium, ruthenium and tungsten among other metals. Today, these metals are generally mined from Earth's crust and form an essential stuff for our economic and technological progress. From one point of view, it is believed that mining the asteroids would be relatively easy because, unlike our Earth, most valuable deposits are located near the asteroid's surface rather than near the core. But the only obstacle is to reach there!

Even without a manned mission to do a full-scale study of an asteroid, scientists know a lot about what these bodies contain from Earth-based measurements. Astronomers use telescopic spectroscopy which analyzes light reflected from the asteroid's surface, to find out their composition. In addition to metals like Iron, Nickel and Magnesium, scientists think Water, Oxygen, Gold and Platinum also exist on some asteroids. Water interests space explorers most, because it could help keep a space colony alive as without water, there is really no way to move ahead with human exploration of space. Water could also be broken down by the method of electrolysis using sunlight into its constituent elements such as Hydrogen and Oxygen to form rocket engine propellant. The metals mined and extracted from the asteroids could also be used for building spacecraft and other structures for a space colony that would further ease asteroid exploration.

Asteroid Extraction and Processing

The drive to set up a sustained mining operation in place on an asteroid is , by no

means, an easy task. While building an asteroid mine will cost billions of dollars, it will be far cheaper than carrying supplies from Earth to the Moon or Mars. Spacecraft would have to carry food and supplies for the mining crew and the equipment for mining activities. Newly developed spacecraft should make landing on an asteroid possible. After all, man has already landed on the Moon and some asteroids pass-by closer than the Moon from the Earth. A spacecraft going to an asteroid would need less rocket power and fuel than one going to the Moon. One problem will be how to keep the asteroid from rotating while it is being mined. Some experts suggest attaching rockets to the asteroid to take the spin out of it. But once miners land on the asteroid, they have to plan to dig it for minerals, process the materials extracted and transport it to a space colony orbiting around the Earth or directly to the Earth itself. Although no one knows for sure what the first asteroid mine will look like, there are some good assumptions about them which are outlined below:

Asteroid mining activities would involve drilling boreholes and injecting hot liquid or gas and allowing the useful materials to react or melt with the solvent and extract the solute. Due to the weak gravitational fields of asteroids, any activities, like drilling or boring, will cause large surface disturbances to eject plumes of dust clouds. These might be confined by some dome or bubble barrier, or else some means of rapidly dust dissipating mechanism should be provided for to get rid of these dusts. Mining operations require

special equipment to handle the extraction and processing of ore in outer space. The machinery will need to be anchored to the body of the asteroid; but once in place, the ore can be moved about more readily due to the lack of gravity. However, no technique for refining ore in zero gravity conditions currently exists. Docking with an asteroid might be performed using a harpoon-like process, where a projectile would penetrate the surface to serve as an anchor; then an attached cable would be used to winch the vehicle to the surface if the asteroid is both penetrable and rigid enough for a harpoon to be effective.

The machinery will likely to be solar-powered to reduce the need for fuel that would have to be hauled to the asteroid by a spacecraft. All the equipment should be light-weight for easy transport to the asteroid. Most equipment will be robotic in nature to reduce the need for manpower to carry out mining activities. This would bring down the amount of supplies, like food and other essential items required for a long manned mission. Miners on asteroids would use techniques similar to those on the Earth. The most likely method will be to scrape desired materials off the asteroid and tunnel into veins of specific substances. Scraping or Strip mining will pull out valuable ore that will float off the asteroid. Because much of the ore will fly off, a large canopy might be used to collect it. As the asteroids have little gravity, the mining equipment, and the astronaut miners who operate them, will have to use grapples to anchor themselves securely to the ground. However, the lack of

gravity is an advantage in moving mined materials around without having to use much muscle power. Once a load of materials is ready to be sent to the Earth or to a space colony around it, rocket fuel for a ferrying spacecraft could be produced by breaking down water harvested from the asteroid into Hydrogen and Oxygen molecules. After an asteroid's minerals and resources have been completely exhausted by the mining project, the mining equipment can be shifted to another potential asteroid candidate for further mining without bringing them back to the Earth.

Economy of Mining

Currently, the quality of the ore and the consequent cost and mass of equipment required to extract it are unknown and can only be speculated. Some economic analyses indicate that the cost of returning asteroid minerals to the Earth far outweighs their market value and that asteroid mining will not attract private investment at current commodity prices and space transportation costs. Other studies suggest that large profit could be made by using solar power.

In 1997, it was speculated that a relatively small metallic asteroid with a diameter of 1.6 km (1 mile) contains more than US\$20 trillion worth of industrial and precious metals. A comparatively small M-type asteroid with a mean diameter of 1 km (0.62 mile) could contain more than two billion

metric tons of Iron–Nickel ore, or 2 to 3 times the world production of 2004. The asteroid 16-Psyche is believed to contain 1.7×10^{19} kg of Nickel–Iron, which could supply the world production requirement for several million years. In fact, a small portion of an asteroid's extracted material would be a precious stuff in comparison to our Earth's standards!

Not all mined materials from asteroids would be cost-effective, especially for the potential return of economic amounts of material to the Earth. For a potential return to Earth, Platinum is considered very rare in terrestrial geologic formations and, therefore, is potentially worth bringing some quantity for terrestrial use. Nickel, on the other hand, is quite abundant on Earth and is mined in many terrestrial locations; hence, the high cost of asteroid mining may not make it economically viable. The development of an infrastructure for altering an asteroid's orbit to our technically favourable locations could make our mining activities easier and would offer a large return on investment.

Hence, if our dream of mining the asteroids comes true, our planet Earth would be richer by many counts by plundering the asteroid wealth!

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Education Officer
Regional Science Centre
Bhopal
Phone : 8917637974



INTERNET OF THINGS, MACHINE LEARNING & CYBER PHYSICAL SYSTEMS: NOW AND THE FUTURE

7

¹Subhranshu Sekhar Samal²Ashank Bharati³Amrita Samal

Artificial Intelligence (AI) and Machine Learning (ML) have become quite hot these days, and almost everyone is excited about it. In the year 2020, nearly 20 billion objects have become a part of this network, and experts say that by 2025 it will be nearly 80 billion. Also quite fantastic quality of systems based on AI and ML have been made which are used extensively these days by almost every industry sector round the globe, be it agriculture, irrigation systems, weather forecast, smart home systems, manufacturing companies, e-commerce businesses, automobiles and whatnot. Even India is expected to reach more than 15 billion USD, in terms of market, which can be of significant value in the global market, given that a decent number of start-ups/IT firms are choosing, Artificial Intelligence in general, Machine learning/Deep learning in particular as the base technologies for their products.

Components

The Internet of Things connects the physical world with the virtual world. A number of objects assisted with dedicated sensors connected to the internet through a local interface, like Wi-Fi, share the data collected via sensors with each other over a secure

cloud platform as a middleware, where all the computation and analysis happens.

It is a result of several complementary technical components which have certain capabilities, as the following:

1. Communication and Mutual Interaction:

Objects have the ability to network with Internet resources or even with each other, to make use of data and services and update their state. Wireless technologies such as GSM and UMTS, Wi-Fi, Bluetooth, ZigBee and various other wireless networking protocols, particularly those relating to Wireless Personal Area Networks (WPANs), are of primary relevance here.

2. Addressability: The objects can be located and addressed via discovery, look-up or named services, and hence remotely interrogated or configured.

3. Identification: Objects are uniquely identifiable. RFID, NFC (Near Field Communication) and optically readable bar codes are examples of technologies with which even passive objects which do not have built-in energy resources can be identified (with the aid of a “mediator” such as an RFID reader or

mobile phone). Identification enables objects to be linked to information associated with the particular object and that can be retrieved from a server, provided the mediator is connected to the network.

4. Sensing: Objects collect information about their surroundings with sensors, record it, forward it or react directly to it.

5. Actuation: Objects contain actuators to manipulate their environment (for example by converting electrical signals into mechanical movement). Such actuators can be used to remotely control real-world processes via the Internet.

6. Embedded information processing: Smart objects feature a processor or microcontroller, clubbed with storage capacity. These resources can be used, for example, to process and interpret sensor information, or to delegate products to a “memory” system of how they have been used.

7. Localization: Smart things are aware of their physical location, and can be located easily by leveraging technologies like GPS, ultrasound time measurements, UWB (Ultra-Wide Band), radio beacons (e.g. neighbouring WLAN base stations or RFID readers with known coordinates) and other optical technologies.

8. User interfaces: These objects can communicate with users in an appropriate manner either directly or indirectly, for instance, via a smartphone, a smart watch, etc.

Machine Learning

Machine learning branches out from a

science which deals with development and study of algorithms which can think, or perform tasks like the human brain, known as Artificial Intelligence. Machine Learning comes with a set of tools to train an algorithm which can then be embedded on to a machine or computer system, to do some smart, intelligent analysis or computations.

ML can be classified as:

1. Supervised learning
2. Unsupervised learning
3. Reinforcement learning

Supervised learning is a way of training a model with available labelled data, i.e. the machine would be able to predict or classify on the target values of an unknown variable based on past data that was fed to the machine while training it. It finds vast applications especially with respect to business models like customer segmentation, churn predictions, recommendation systems, etc.

Unsupervised learning is a way of training a model wherein no labelled data is available. A set of available data or objects are clustered to form groups and do analysis/predictions on the basis of clusters and their behaviours. The machine models trained with this technique are used for applications like anomaly detection, visualisation with clustering, and finding association protocols, etc.

Reinforcement learning is a way of training a model wherein the machine always has a notion to improve with a concept of cumulative reward. The model learns by taking certain



actions which would maximise the possibility of reward. The models trained on this learning are used for applications such as robotics for motion control and industrial automation, business strategy planning, a plethora of medical appliances, etc.

Deep Learning is a subset of Machine learning wherein a model is trained just like a human brain works, with a network of multiple layers of nerve cells called neurons. A similar multi-layered neural network is replicated in order to train a model. Deep learning can be supervised, unsupervised, or reinforced. Deep learning is based on architectures like convolutional neural networks, artificial neural networks, deep neural networks, and recurrent neural networks, which have been applied to various applications like computer vision, speech recognition, and language processing, etc.

Multidisciplinary Applications for Industries and Society

1. Industrial Applications for Cost Savings

Industries use various ultrasonic sensors in or around their machines, feeding millions of data every day to their machine learning algorithms, wherein the algorithm learns whatever is necessary for the machineries to operate at their best. Goldcorp is a mining company which uses several vehicles and machines to move their materials and a sudden breakdown in their machines costs them around 2million dollars per day. Goldcorp takes pride in being smart and leveraging the boon of with ML, thereby being able to monitor its machines 24x7.

2. Smart Home

Manufacturers have been working on adding more intelligence and connectivity into household objects and appliances for more than a decade – Electrolux, for example, mooted the idea of an Internet-connected fridge in 2000. These early innovators envisaged a world in which consumers would have remote control over their homes and all their appliances, enabling them to easily see if they have enough milk, turn off the central heating, unlock the front door and check on elderly relatives from just about anywhere. Now, the falling cost of wireless hardware, the expansion of mobile networks, the development of new business models and the spread of smartphones, is enabling that vision to become a reality.

3. Security Systems

Connected security systems typically make use of sensors to monitor when doors or windows are opened and when there is movement within the property. There are also home automation systems which enable elements of the home to be remotely controlled, so householders can lock and unlock doors, for example, using their smartphone. These systems are also used nowadays for a set of security applications like *face recognition* - to track if a stranger try to enter your house, *smoke detection* - in order to detect some fire breakout or gas leakage at your home, sound analysis, etc. Companies like Rapid7, SimpliSafe, Ring, Fluidmesh Networks, etc. are one of the market leaders with respect to ML security systems.

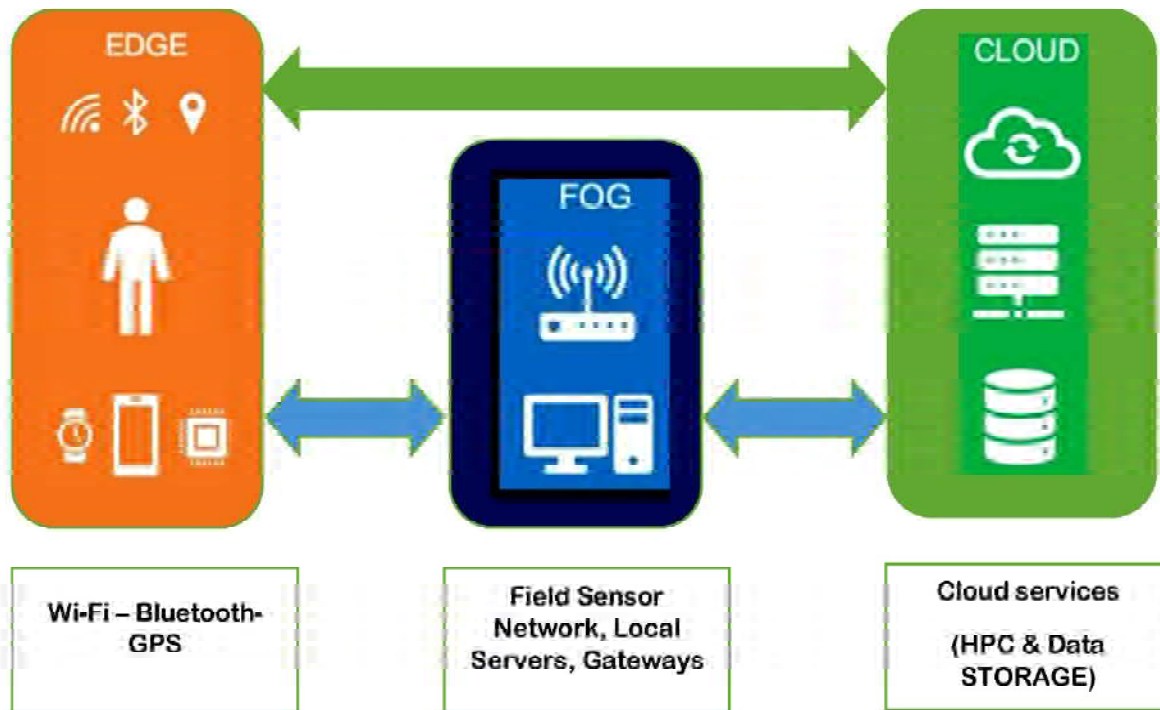


Fig: 1 - Tier architecture for *Internet of Medical Things (IoMT)* - Systems
 [Reference: Trends in based solutions for health care: Moving AI to the edge]

4. Health Care

Health Care devices and intelligent medical sensors are drastically changing the way health care systems are accessed globally. A broad application of these smart sensors across wearables that are used nowadays by a decent part of society, facilitate the regular monitoring of an individual's health, on parameters like pulse rate, etc, and derive intelligent results/conclusions based on the individual's behaviour with help of Machine learning/Deep learning. This not only increases the speed and efficiency of diagnosis, but also reduces the huge amount of costs spent on doctor's visit and medicines.

The above figure-1 represents a three tier architecture of how a basic *IoMT* system is based:

1. *1st level* - consists of the direct user interfaces in form of hardware wearables, like smart watches, smart phones, etc, which do some pre-processing, and a level of elaboration on the data collected from their body sensors.
2. *2nd level* - consists of the gateway, in form of field sensor networks, or local servers/gateways, which acts as a middleware between 3rd level and 1st level.
3. *3rd level* - this level marks the layer of cloud services, which performs high performance computing, data storage and smart analytics guided by ML/DL, in order to produce important insights.

Similarly, and ML/DL systems are used



for various medical appliances like X-ray machines, MRI scanners, CT scanners, etc. for diagnosing some disease/ dysfunction in the human body, without much manual intervention from a doctor. And these are just a handful of use cases, among the virtually numberless possibilities that have been and also can be unlocked using multidisciplinary aspects of and Artificial Intelligence, for fulfilling a number of necessary social and economic goals.

Technological Challenges

While the possible applications and scenarios outlined above may be very interesting, the demands placed on the underlying technology are substantial. Progressing from the vast network of computers to the remote and somewhat fuzzy

goal of an Internet of Things is something that must therefore be done one step at a time. In addition to the expectation that the technology must be available at low cost if a large number of objects are actually to be equipped, we are also faced with many other challenges, such as: *scalability, arrive and operate, interoperability, discovery, software complexity, data volumes, data interpretation, security and personal privacy, fault power supply & wireless communications.*

Government of India Initiatives

1. National Mission on Interdisciplinary Cyber Physical Systems (NM-ICPS):
National mission on India's initiative through "National Mission on Interdisciplinary Cyber Physical Systems (NM-ICPS)" is a great step towards encouraging research on AI, Deep

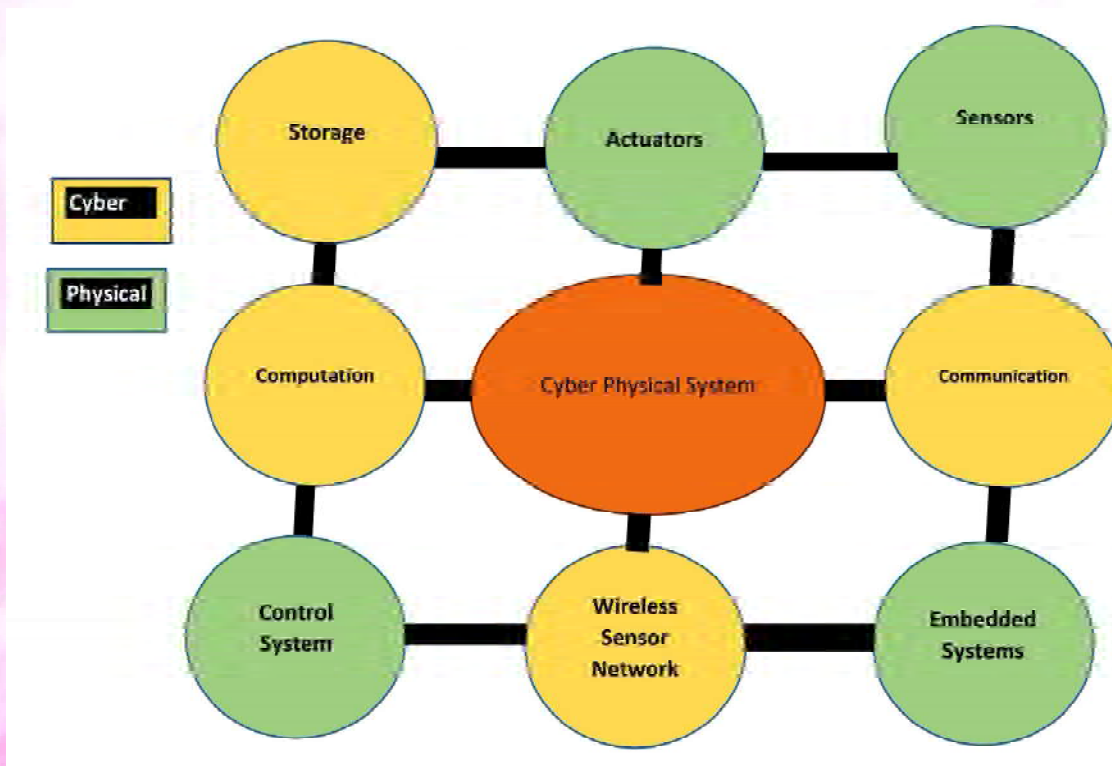


Fig.2: Schematics of Cyber Physical System

learning, Machine learning and physical systems. The mission will be implemented through a network of 15 Technology Innovation Hubs (TIHs), 6 Sectoral Application Hubs (SAHs) and 4 Technology Translation Research Parks (TTRPs). The preliminary phase has aimed at establishing hubs on:

- √ Artificial Intelligence and Machine Learning,
- √ Technologies for Internet of Things and Everything (& IOE), Sensors, Activators and Control
- √ Databanks & Data Services, Data Analytics
- √ Advanced Communication Systems
- √ Robotics & Autonomous Systems
- √ Cyber Security and Cyber Security for Physical Infrastructures

The mission has been planned to achieve objectives like:

- ◆ Knowledge Generation through basic and applied research
 - ◆ Technology/Product Development and Commercialisation
 - ◆ Meeting Industry requirements
 - ◆ Develop international collaborations
 - ◆ Transforming technology from lab to land
 - ◆ HRD and Skill Development in the area of ICT & automation
2. NIELIT, Calicut (Under MeitY, GoI) has started Certificate course on Cyber Physical Systems

3. NITI Aayog has launched National Policy on Artificial Intelligence ‘AI for ALL’
4. India–Sweden Collaborative Industrial Research and Development Program on AI to be implemented by Global Innovation & Technology Alliance (GITA) from India and Vinnova in Sweden.
5. Department of Biotechnology (DBT) announced call for AI applications for the ‘Affordable and Accessible Healthcare – Big Data and Genomics’ initiative which will attract scientists and researchers from multi-disciplinary domains in data science, computational biology, statistics, machine learning, and deep learning.

Academic Initiatives

The educational institutions as well as universities across India have started degree (BTech/MTech/PhD) courses as well as offering short courses (Certificate/Diploma/PG Diploma) on AI and Machine Learning. The initiatives taken by universities and colleges will enhance the specialized manpower to compensate the demand in coming days. The awareness and outreach programmes funded by govt. agencies are executed by various establishments in the area of AI and ML. Nearly 40 universities and institutions are offering courses (degree and short-term) courses on AI and Machine Learning to support the capacity building in AI and ML. More than 70+ universities and institutes are offering degree/diploma/

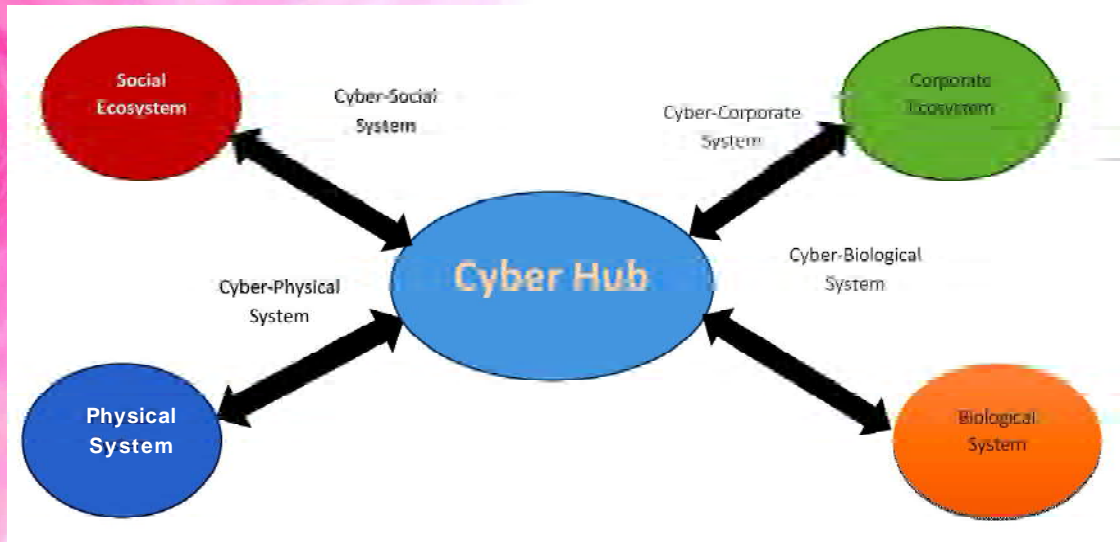


Fig.3. Cross disciplinary emerging Cyber Systems in Industry 4.0

certificate courses on AI and ML.

Future Directions and Way Forward

IoT, AI and Machine learning have impacted the lives of common man in various ways. Starting from good morning till good night we are impacted by the huge impact of cyber physical systems in our day to day lives. May it be forecasting the climate conditions or booking a cab to reach office and predicting traffic or congestion on the road, AI and ML is playing a major role for our life style. National security, climate prediction, agricultural forecast and financial market are getting updated every second by the impact of AI and ML. The industrial revolution 4.0 will lead to the emergence of not only cyber physical system, it will create room for cyber social, cyber biological and cyber corporate systems which are interdisciplinary in nature.

Industries and Govt have taken various initiatives for the growth and implementations of various schemes and upgradation of

technologies in the area of AI and ML. Hope our needs and advancements in technologies may end up in a positive direction for the growth of our country like India. The impact of AI and ML have shown their impact in domains of social life, defence, security, health, hygiene, transportation and infrastructures of our country. The initiatives have shown us the way for the success of the scheme like Digital India, Start-up India, Make-in- India, Skill India and Atmanirbhar Bharat. Road to success is always under construction and we have to move with positive thoughts and energy for creating a healthy ecosystem and a true “Atmanirbhar Bharat”.



¹CEO, Atal Incubation Centre-AUDF
(Sponsored by AIM-NITI Aayog)
New Delhi

²R & D Lead (SDE-2), Nuclei, Bangalore

³Deputy Chief of IT
AIASL-New Delhi

THE INTERPLAY OF BIOLOGY AND TECHNOLOGY

8



¹Dr. Taranisen Panda
²Dr. Raj Ballav Mohanty

The journey of understanding life and the cell is a fascinating one. In 1665, Robert Hooke peered through an early microscope and unveiled microorganisms, describing them in his book “Micrographia”. A few years later, in 1676, Antonie van Leeuwenhoek, a Dutch draper with a knack for crafting simple microscopes, discovered bacteria, which he charmingly referred to as “animalcules”. Over the next 150 years, these findings were corroborated, although microscopes weren’t readily accessible. It was in 1839 that Matthias Jakob Schleiden and Theodor Schwann stated the fundamental principle of cell theory: “All living things are composed of living cells”. However, the belief in spontaneous generation, where life emerged from non-living matter, still persisted. In 1855, Rudolf Virchow proposed the “Biogenic Law”, declaring, “All living cells arise from pre-existing cells”. Schleiden, Schwann, and Virchow collectively laid the foundation for the Cell Theory, which is upheld today. This theory revolutionized biology by establishing cells as life’s basic units and rejecting the notion of spontaneous generation. The concept of spontaneous generation was conclusively refuted by Louis Pasteur in 1859 through a groundbreaking

experiment. He boiled broth in two flasks – one open to the air, the other sealed with an ‘S’-shaped neck and a cotton wool plug. The open flask became cloudy with bacteria, while the sealed one remained clear – proving that life doesn’t emerge spontaneously.

Metabolic pathways play a vital role by allowing cells to capture energy from their surroundings, essential for maintaining their order. The intricate dance of cellular processes keeps life’s flame burning. Moreover, Schrodinger introduced the idea of a code script within cells, an ‘aperiodic crystal’, which we now recognized as DNA. DNA, with its ordered yet irregular structure, contains the instructions for life was announced by James Watson and Francis Crick in 1953. DNA is indeed life’s cornerstone. It’s indispensable for producing messenger RNA (mRNA), proteins, replication, and evolution. Without it, cells can’t survive, replicate, or adapt. Losing genetic information results in cell death in a matter of minutes to days, except for red blood cells, which lack DNA and need regular replacement.

Biotechnology is a rapidly advancing field of biology that’s shaping our lives. It uses

organisms and biological processes to create new technologies, improving sustainability and productivity. One important technique in biotech is Recombinant DNA Technology (RDT). RDT involves taking a gene from one organism and inserting or modifying it in another using a carrier molecule called a vector. This creates a new DNA molecule, often making a Genetically Modified Organism (GMO) with a unique combination of genes that wouldn't naturally occur together. This technology allows us to manipulate genes to benefit various aspects of life. This technology has applications in medicine, agriculture, energy, manufacturing, and food, benefiting society in various ways. Advancements such as automated oligonucleotide synthesis and polymerase chain reaction (PCR) have paved the way for significant improvements in the field of recombinant DNA technology. Automated oligonucleotide synthesis allows for the precise and efficient production of DNA or RNA sequences, including synthetic genes or specific DNA fragments, which are essential components in the construction of recombinant DNA molecules. PCR, on the other hand, revolutionizes the amplification of target genetic material, making it easier to clone and manipulate specific DNA segments.

One of the most transformative ideas introduced by synthetic biology pioneers like Drew Endy and Tom Knight is that DNA should be “fabricated” instead of being handcrafted. Synthetic biology is about taking apart and rebuilding biological cells and processes to create new systems that can do useful things.

It uses DNA to encode designs. DNA is used to make biological parts, and these parts are put together to create devices. These devices are then integrated into biological systems. Computers play a pivotal role in every step of this process, from modeling and planning to using robots for automating the assembly and experiments. Synthetic biology follows engineering principles like standardization, modularity, and abstraction. This makes it easier to quickly try out new ideas and share them with other synthetic biologists worldwide. The applications of synthetic biology are broad. It can help in healthcare by improving diagnostics and treatments for diseases. It can also benefit the environment by finding new ways to clean up pollution, making sustainable chemical processes, and developing better fertilizers. Ultimately, synthetic biology has the potential to change the way we live and protect our planet's future.

A compelling example of synthetic biology in medicine is the creation of synthetic vaccines. In this application, scientists use genetic engineering to modify microorganisms, enabling them to produce antigenic proteins resembling specific pathogens, such as viruses. These synthetic vaccines are meticulously designed to trigger a strong immune response without actually causing the disease. What makes them remarkable is their adaptability; they can be tailored to combat distinct diseases, whether it's influenza or the latest viral outbreak like COVID-19. Synthetic biology's prowess in swift vaccine development has the potential to

transform our approach to tackling infectious diseases and managing outbreaks in the future. Another example, Januvia, a diabetes medication by Merck, works by increasing insulin release through the inhibition of dipeptidyl peptidase 4. It's one of the most prescribed drugs for diabetes. However, its active component, sitagliptin, is complex to synthesize chemically due to a particular amine. To overcome this, scientists used computational design and evolved a specific enzyme from *Arthrobacter* sp., making it versatile for synthesizing sitagliptin and other drugs like the HIV antiviral islatravir. This enzyme has undergone extensive enhancements and can produce high-purity compounds, even for challenging molecules with fluorine or alkyne groups. This approach streamlines drug manufacturing.

One recent and revolutionary technology in biology is CRISPR-Cas9 gene editing. CRISPR stands for "Clustered Regularly Interspaced Short Palindromic Repeats," and Cas9 stands for "CRISPR-associated protein 9." Together, CRISPR-Cas9 is a powerful tool that allows scientists to make precise changes to the DNA of living organisms. This technology has garnered immense attention in recent years because it enables the targeted modification of genes in a wide range of organisms, offering groundbreaking possibilities in genetic research, medical treatments, and agriculture. With CRISPR-Cas9, researchers can edit genes to correct genetic mutations, potentially curing genetic diseases. In agriculture, it has the potential to

modify crops for improved sustainability, making them more resistant to pests and environmental stress. In the field of medicine, CRISPR-Cas9 holds promise for the development of novel therapies to treat various health conditions, including those with a genetic basis.

In conclusion, the dynamic interplay between biology and technology has significantly transformed our understanding of life and ushered in remarkable changes in our relationship with the environment. The foundational principles of cell theory, coupled with the power of DNA, have collectively reshaped the landscape of biological sciences and have become the cornerstone of our understanding of life. The fusion of biology and technology has given rise to pioneering areas, including biotechnology, synthetic biology, CRISPR-Cas9 gene editing, and various other cutting-edge technologies, allowing us to tailor the creation of biological systems to meet our specific needs. These advancements have not only deepened our understanding of life at the cellular and molecular levels but have also unlocked doors to innovative applications that touch every aspect of our lives. From the development of synthetic vaccines customized to combat infectious diseases to the streamlined production of life-changing medications, the impact of these technologies on medicine and healthcare is undeniable. In agriculture, they offer solutions for sustainable food production and environmental preservation. Furthermore, the potential to treat and even cure genetic



diseases using gene editing technologies provides hope for countless individuals and families. As we stand at the threshold of a new era where biology and technology are intricately linked, it is imperative that we continue to harness these powerful tools responsibly, with careful consideration of their ethical and social implications. The journey of understanding life at the cellular and genetic levels and the transformative applications that emerge from this understanding is a testament to human ingenuity and the unwavering commitment to improving the human condition and safeguarding our planet's future. In the years ahead, we can anticipate even more groundbreaking discoveries and innovations that will continue to reshape our world, paving the way for a brighter, healthier, and more sustainable future. The interplay of biology and technology is an ongoing, captivating

journey, promising to lead us to uncharted frontiers.

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¹Department of Botany, Chandbali College, Chandbali, Bhadrak- 756133, Odisha, India
Email: taranisenpanda@yahoo.co.in

²Ex-Reader in Botany, Plot No. 1311/7628, Satya Bihar, Rasulgarh, Bhubaneswar, Odisha, 751010

Artificial Eggs and Sperms

Katsuhiko Hayashi, developmental geneticist at Osaka University in Japan has recently claimed to have created artificial eggs and sperms. This is called in vitro gametogenesis or IVG. The discovery has created excitement and controversy among biologists. The goal of IVG is to make unlimited supplies of artificial eggs and sperms from any cell in the human body. That could let anyone—older, infertile, single, gay, transgender—have their own genetically related babies.

IVG would render the biological clock irrelevant, by enabling women of any age to have genetically related children. Prospective parents would be able to minimize the chances their children would be born with detrimental genes. IVG could also lead to “designer babies”, whose parents pick and choose the traits they desire.

Researchers at biotech start-up called Conception, based in California, claim that they are about to lap the Japanese scientists. They say that they will be ready to make human eggs to fertilize for making human embryos.

Like many other new technologies and innovations, IVG would raise serious moral, legal and societal issues.

- Editor

TRADITIONAL COMPUTING AND PRESENT-DAY AI

9



Dr. Nikhilanand Panigrahy

“When Henry Ford made cheap, reliable cars, people said “Nah, what is wrong with a horse?” That was a huge bet he made and it worked”.

*- Elon Musk (Born in 1971,
Pretoria, South Africa)*

Henry Ford (1863-1947, Birth place : Spring wells Township, Michigan, USA) established officially the Ford Motor Company in 1903 and could finally produce cheap cars for the middle class, who never dreamt to afford to own a four-wheeler, as at that time only luxury cars were available, basically meant for highly rich and aristocratic people. Initially he was laughed at and ridiculed as people neither believed in this project nor him, because, prior to this project, he had suffered several failures in business - ventures.

Any invention or innovation normally faces derision, disbelief and bitter criticism of the public, who of course, later on welcome the same, after being sure and familiar with its advantages. So also is the case with Artificial Intelligence (AI).

John McCarthy (1927-2011, Birth place: Boston, considered as father of AI) along with Marvin Minsky (1927-2016, Born at New York City), Nathaniel Rochester (1919-2001, Born at Peto Skey, Michigan) after coining

the word “Artificial Intelligence”, presented the same at the Dart mouth conference (1956), after which it was started as a new field. It has been evolving since then. After so many years, it is no longer treated as a strange, wild animal and a dreadful thing.

It is well-known that computers are being used for various purposes like online bill payment, watching movies or shows at home, social media access, electronic mail, playing games, internet access etc at present. In this context it is useful to remember that a smart phone is “a portable computer device where mobile telephone functions and personal computing functions are kept in a single unit.” But it was not so, at the time of its invention. Now it has encompassed a large segment of people, from children to the old. Many people often wonder how it is able to perform our day-to-day works of varied kinds, quite smoothly and in a short period.

But to achieve such amazing results, there has been an elaborate and flawless arrangement. There are some basic things behind this:-

First of all there should be a program, which a computer uses for the specific task, we want. This should have a set of instructions,

which are created by high-level programming languages, that are human-readable/writable (like C++). The high-level language then needs to be translated to low-level machine language by computers, assemblers within the computer system. This is fed into a software. When we purchase a software from the market, we find that it has final version of a programme, which is already assembled in machine and ready for use. Often a software contains several individual programs. The success of a program depends on a detailed unambiguous and ordered plan or procedure for solving our intended work.

Even though technical words like programs and Algorithm are used interchangeably, there is a fine distinction. Algorithm is a high-level description of an idea, whereas program is the actual implementation of that idea.

Algorithm is one of the important elements in the context of use of computer. This word may appear as difficult and technical to the layman. But one can understand its meaning, if it is compared with different works, which normally are performed in this daily life. For example, preparing a dish in the kitchen. This is very familiar to us. Every body knows that there should be a method to prefer the desired, particular kind of recipe.

If a vegetable curry is required, in addition to the a utensils and oven, one arranges potato, carrot, cauliflower, vegetable oil, onion, curry powder, tomatoes, spinach, spices etc as per his liking. He has to collect the ingredients at one place. Besides, he has to chop tomato, potato and start cooking. But if he has forgotten

salt to have with him, or, in case, the cooking gas-supply is hampered, he may desist from his efforts. Anyway this procedure may be called as ‘Algorithm and the ingredients as ‘data’.

But this procedure and data will have another shape, if he is interested to cook chicken Tikka Masala. Not only the procedure, the ingredients will also be quite different. Thus the ‘data’ and consequent algorithm, if we say so, will have to be altered. “Basically algorithm is a technique to solve a problem and data is information such as facts and numbers, used by a computer to analyse something, or make decision. Data base is an organized collection that is stored. However if it is organized and stored in such a way that it is always easy for accessing and modifying, it is termed as data-structure.”

Anyway, one can cook both vegetable curry and chicken Tikka Masala in the same kitchen. Likewise, roughly we can say that one can store a group of algorithms in a single software. It is said that “algorithm is a coded formula written into software that, when triggered, prompts the tech to take relevant action to solve a problem.”

Besides our kitchen-experience, there are many incidents, that occur practically in our life, like search for a book in a library, sorting of our files alphabetically/chronologically or any other specification which is nothing but our intention to organize small tasks. We may not be conscious that this is in effect an act of construction of algorithm in our natural mind.

Let us consider tying shoelace, which is very simple and adopted easily by any ordinary man. But if we use a computer for this minor traditional work performed in no time we have to build and follow a very complicated algorithm. This emphasizes how our brains are much superior to an artificial device.

At present we are finding numerous generative AI (Artificial Intelligence) tools companies such as Apple, Alphabet, Microsoft and Meta which have flourished by using AI, they can process large amounts of data much faster with accuracy. This is normally not possible for humans. One of the significant elements behind this is that the data needs to be voluminous, so that, AI applications can quickly turn into actionable information out of such vast resource of data with the help of Machine Learning. The advantage of AI is that a machine, if so made, can think smartly and basically giving it a human touch and thus in a way appears more humanlike.

We can now note AI is capable of doing incredible things, much beyond computers traditionally have achieved. For example, AI already is used more efficiently to diagnose patients based in medical scans like X-Rays. AI models can detect exoplanets; These are planets with a star outside the solar system.

It is heartening to note that AI can also support revamped smart phones. Google and Apple companies have looked into the matter of integrating AI into processors of their newest flagship smart phones, namely the iPhone and the Pixel series of phones. It has been quite possible that the smart phones

could also lead the transition of devices towards Machine Learning. They can also use Artificial Intelligence in the near future. The revamped smart devices can upgrade the user experience. (Ref. “Artificial Intelligence on Smart Phones-why it is important”, Omer Khatkhatay, 6th May 2022, linkedin.com).

This remark has much relevance for India, looking at the widespread use of digital network in our country. The essential necessity for Indian smart phone users now is to welcome its impending revamped smart phone, where AI is being in-corporated, at present.

It may be significant to keep in mind that our five senses (i.e, ear, eye, nose, tongue and skin) enable us to listen/talk, watch, remember, think and act. Similar to the perception of human intelligence, the AI combines five senses to create a cognitive solution. Thus AI can find solutions to our problems in such a way that it can deliver ‘responsive, relevant and intuitive user experiences.’

Its effect appears as nothing but wonders, as would appear in the following instances :

Suppose one drives his car to a particular spot in a parking space, but finds no vacancy. Then he moves on from one spot to another till he gets a suitable area. He will be spared from this trouble with the application of AI, which can offer an instantaneous easy solution.

Consider another example. In the waiting room of a hospital, we find all sorts of patients sitting together. It is quite possible that some of them are suffering from infectious diseases. It is essential that these persons need to be



separated from others. AI can, not only count the total number of people in the gathering, but also suggest ways and means to put them in separate blocks. Such a lead based on an observation at that moment will enable the hospital authorities to organize steps for their treatment, taking into account the facilities, as available in their treatment center.

In many places AI has already entered into our daily lives. For example a device like Alexa, Siri can play a desired song, when we unlock our phone, through face recognition or our verbal command. These are mostly examples of conversational AI, based on machine learning and natural language processing. Besides we have now chat GPT (Chat Generative Pretrained Transformer) which is mostly focused on conversational interactions. “It can answer questions, write essays, summarise documents and write software, even though, deep down, it does not know what is true. Its answers are derived from huge volume of information, available in internet.” It may be mentioned that Chat GPT is another name of generative AI. It is merely a specific implementation of Gen AI, ‘which, however, uses complex algorithms and deep learning and large language models to generate new content, based on data.’

Anyway society is concerned with the wide and wild spread of AI. This uneasy situation has been analysed by many thinkers. For example, Ms Gita Gopinathan, First Deputy Managing Director, IMF, has termed AI as an innovation which is important, but a different kind of animal. This needs regulation for benefits of humanity. She says that

traditionally a new technology causes a lot of lay offs and does not really help to create jobs initially. But later on a lot more jobs are created in different sectors which demand different skills. So, there will be employees who get affected and lose jobs.” This is her insightful observation, based on her vast experience about worldwide financial and societal matters.

There is a fear that generative AI will finally end our creative activities. When this question was put to the eminent writer of Kannada Novel ‘Ghochar Ghochar’, Vivek Shanbhag (also known as Indian Chekhov’, his reply was: “Is artificial intelligence a threat to creative writers? I don’t think so, because artificial intelligence can’t surprise you. It creates something from what is already there, while good writing creates something which is not there. Also good writing always says something, but means some other thing else, which is very difficult for AI to achieve, at least for now.” (Ref: Sunday edition, Times of India, 1st Oct. 2023).

In conclusion, we should remember Henry Ford. When he introduced cheap cars, people mocked him, preferring traditional horse ride to car driving. But ultimately cars have won the day. Any technological innovation causes such an “infavourble flutter in the public initially. But finally the society adopts and welcomes it.” So also AI will enjoy a wide spread warm acceptance.

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Badakhemundi Bungalow,
Utkal Ashram Road, Berhampur-760001
Mob.: 9078743843
E-mail: nokhilanand.panigrahy@gmail.com

QUANTUM TECHNOLOGY

Quantum technology is based on the principles of quantum mechanics developed in the early 20th Century to describe nature at the scale of atoms and elementary particles. 'Quantum' means 'discrete' and quantum physics, first discovered by Max Planck in 1900 describes matter or light existing as discrete packets. Scientists developed quantum mechanics from this and now engineers have transformed this into technology.

Four domains of quantum technologies are quantum computation, quantum simulation, quantum communication and quantum sensing. Quantum computing technologies revolve around the development of quantum computers. The conventional computers store information as bits with a value of either 0 or 1, but the quantum computer stores the information in quantum bits or qubits which can take the values 0 and 1 simultaneously by using the principle known as quantum superposition. This key ability makes quantum computers extremely powerful compared to conventional computers when solving certain kinds of problems like finding prime factors of large numbers and searching large databases.

Quantum simulations can help us understand the properties of materials. Quantum communication system will offer a secure transfer of quantum information by employing quantum cryptography. Quantum sensing solutions promise the development of ultra-sensitive and precise sensors. Quantum technology has not yet matured for commercialisation due to extreme scientific challenges involved, but lot of research is going on in different countries and we would expect to get its fruits soon.

Quantum technology can be used in secure communication, for networks, disaster management through better prediction, computing, simulation, chemistry, healthcare, cryptography, imaging, biology, molecular design for new drugs and chemicals, efficient solution of linear algebra and optimisation problems and in many other fields.

The Indian Government in its budget for 2020-21 has announced a National Mission on Quantum Technologies & Applications (NM-QTA) with a total budget outlay of Rs.8000 Crore for a period of five years. It is being implemented by the Department of Science & Technology. The technologies to be developed under this mission are quantum computers and computing, quantum communication, quantum key distribution, encryption, crypt analysis, quantum devices, quantum sensing, quantum materials, quantum clock and so on. The mission will address the ever increasing technological requirements of the society and take into account the international technology trends and road maps of leading countries.

Finance Minister, Nirmala Sitharaman had told about quantum technology in her budget speech, "Quantum technology is opening up new frontiers in computing, communications and cyber-security with wide spread applications. It is expected that lots of commercial applications would emerge from theoretical constructs which are developing in this area".

- Er. Mayadhar Swain

FUTURE ENERGY STORAGE TECHNOLOGY

10



Er. Mayadhar Swain

Electricity is an essential commodity. The progress of a nation depends on the availability of adequate amount of electricity. But one problem is that we have to consume whatever electricity we generate. It cannot be stored except in small amounts in some devices. Further out of the total electricity generated in the world, share of thermal power is about 60 percent. Same is true for India also. Although thermal power technology is a proven one and its fuel coal is available in plenty in many countries, it has the drawback of polluting the atmosphere. Apart from emitting pollutants like carbon monoxide, sulphur dioxide, fly ash and particulates, it is the cause of global warming and climate change because it emits lot of carbon dioxide to the atmosphere. It has been internationally decided to reduce carbon emission so as to keep the global temperature rise within 1.5 degree centigrade above that prevailed at the beginning of industrial revolution. It has also been announced by many countries to achieve net-zero carbon by 2050. So it is obvious that thermal power plants will gradually be phased out and renewable energy will take its place.

Renewable energy is clean and does not emit carbon dioxide. Most prominent and

attractive renewable energy sources are solar and wind. But these sources depend on nature and so give erratic generation. For example, solar energy is available during day time only and without clouds. Similarly, generation of wind energy varies throughout the day depending on the speed of wind. Hence, adequate energy storage facilities have to be developed to store these energy after generation and distribute when demand arises.

At present share of installed capacity of renewable energy sources in India is 31 percent excluding large hydro. This is increasing year by year. Reduction of unit generation cost of solar and wind power is contributing for rise of its share in the total energy of the nation. But one concern is that although share of installed capacity of renewable energy in the country is 31 percent total generation from these sources is 15 percent. The reason being non-availability of energy storage facilities.

Some of the large energy storage technologies which are in experimental stages are described here.

1. Battery Storage

In battery energy storage system, energy

is stored in the form of electrochemical energy. In other words, battery converts electricity into chemical energy for storage and back into electrical energy to perform different works. At solar PV or wind turbine sets, batteries can smooth out the variants in supply, store excess energy when demand is less and release it when demand increases.



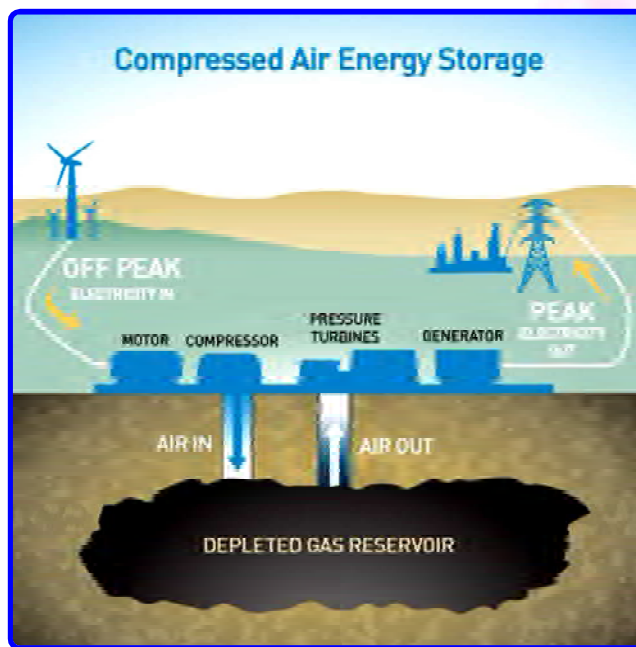
Battery Energy Storage System

There are many battery technologies under consideration for large-scale energy storage. Lead-acid batteries use a low cost technology. But its disadvantages are low energy density and limited cycle life. Lithium-ion (Li-ion) batteries are gaining importance due to its use in Electric Vehicles and electronic gadgets. The Moss landing Energy Storage Facility in Monterey County, California is the world's largest battery storage system. Its capacity is 3000 MWh and it can provide 750 MW power for up to four hours. Even this system is not enough for large size distribution grid.

Although battery storage system is ideal for handling large amount of energy, its cost is more. Research is going on to reduce its cost. Central Electricity Authority has projected a requirement of 23,600 MWh of battery energy storage system in India.

2. Compressed Air Energy Storage

Compressed air energy system requires underground storage in natural or man-made caverns. During off-peak period electricity powered compressors are used to force air into underground voids at a very high pressure. When required, the compressed air is released to drive a turbine generator set by mixing it with fuel and heating it. This is a long term energy storage technology.

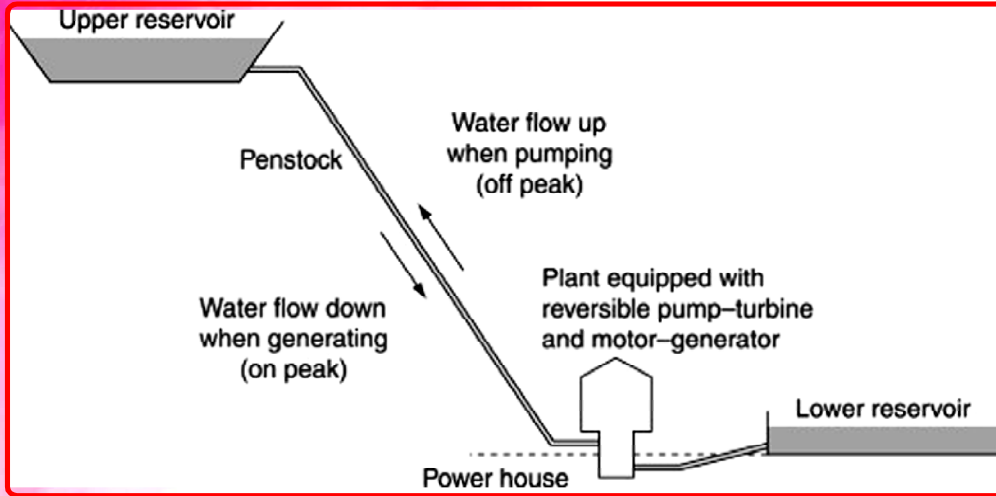


Compressed Air Storage System



3. Pumped Hydro Storage

Pumped hydroelectric energy storage system utilizes the energy in the form of potential



Pumped Storage Scheme

energy of water that is pumped from a lower level reservoir to a higher level reservoir. Generally, the lower level reservoir is constructed at the downstream of hydroelectric power plant. During off-peak time, pumps are used to raise the water from the lower reservoir to the upper one. When there is a high power demand (i.e. peak load hour), the stored water is released through hydro turbines to produce electricity. Most often a reversible turbine/generator assembly act as a pump or turbine. It is one of the cost-effective mechanisms to store large amount of energy. This system is efficient, flexible, economical and commercially available on a vast scale.

In 2022, total pumped hydropower capacity in the world

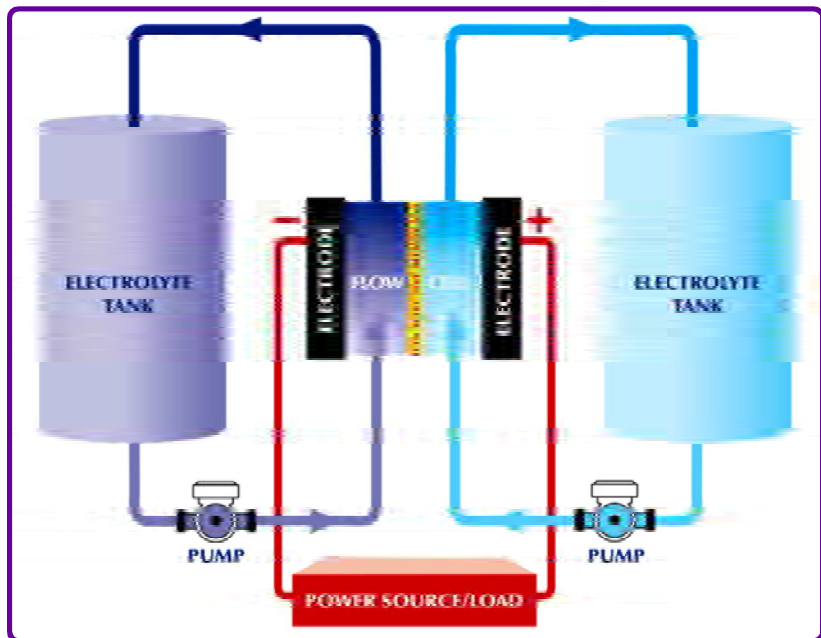
was about 117000 MW. China ranks first with 45800 MW followed by Japan and USA with 21800 MW and 19300 MW respectively. In

India eight number of this system with total capacity of 4700 MW are in operation and four projects of total capacity of 2800 MW are under construction. The government aims to commission 39 projects of 47000 MW capacity by

2030.

4. Flow Battery Energy Storage System

Flow batteries, a newcomer in the industry is a type of rechargeable battery where reversible electrochemical reactions occur in



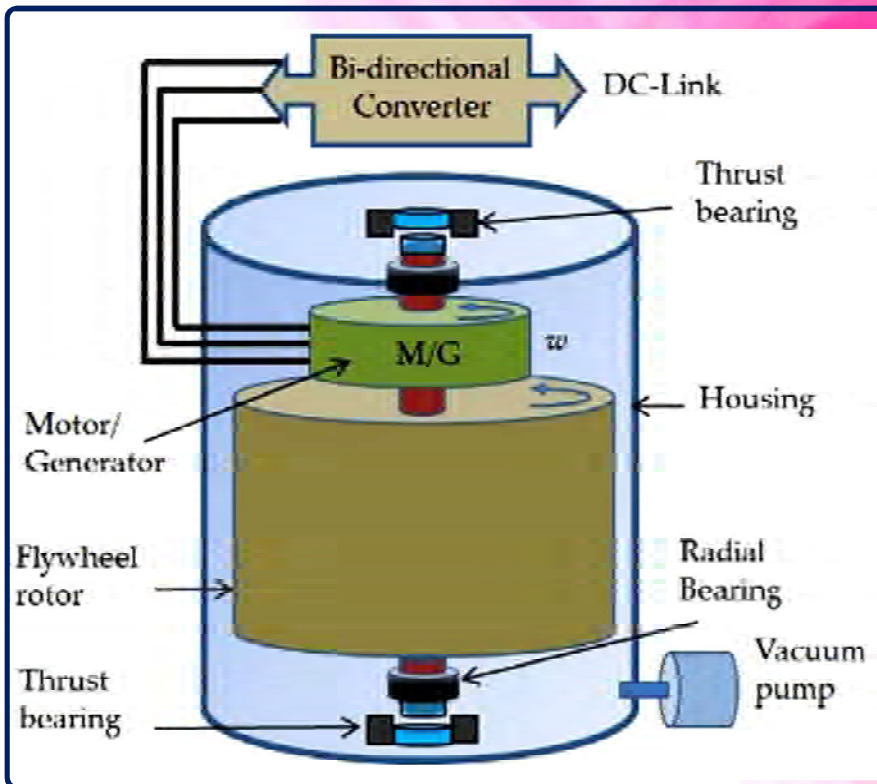
Flow Battery Energy Storage

a set of cells connected in series, parallel or both, in order to achieve the desired voltage. It is provided by two electrolytes and most commonly separated by a membrane. The electrolytes are pumped through the electrochemical cell during normal operation. Fundamental difference between conventional batteries and flow batteries is that energy is stored at the electrode material in conventional batteries, but in the electrolyte in flow batteries. Flow batteries can operate for over 5000 to 10000 cycles or more.

Now, the most advanced flow batteries are vanadium redox batteries (VRBs), which store energy in electrolytes that contain vanadium ions dissolved in water-based solution. Vanadium's advantage is that its ions are stable and can be cycled through the battery over and over without undergoing unwanted side reactions. Other flow battery types include Iron-Chromium flow batteries and Zinc-Bromine flow batteries.

5. Flywheel Energy Storage System

A flywheel consists of a rotating mechanical device that is used to store kinetic energy. It has a spinning mass in its centre that is driven by a motor. Electric energy input accelerates the flywheel to very high



Flywheel Storage

speeds of tons of thousands of RPM (revolution per minute). When energy is required, the spinning force drives a device similar to a turbine.

6. Hydrogen Storage

Electricity can be converted into hydrogen by the process of electrolysis. Then hydrogen can be stored and re-electrified through fuel cells. The efficiency of such a system today is 30 to 40 percent, but could be increased upto 50 percent by developing more efficient technologies.

Small amounts of hydrogen (upto a few MWh) can be stored in pressurised vessels at 100-300 bars or in liquified state at low temperature. Large quantities can be stored in underground caverns upto 50,000 cubic meters





Hydrogen Storage

at 200 bars enough to produce 100 GWh of electricity.

7. Molten Salt Energy Storage

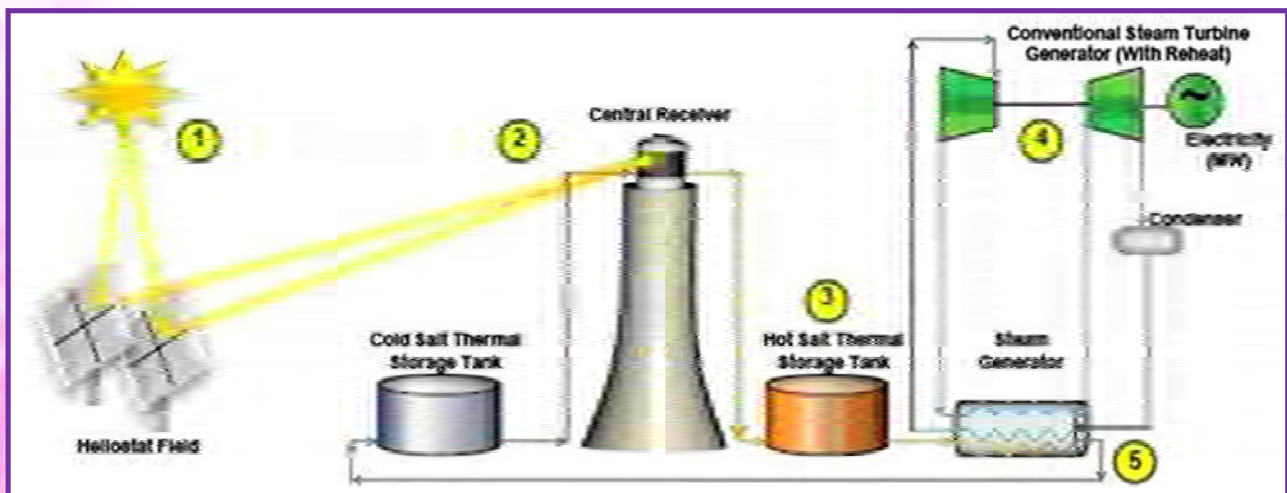
Molten salt is a flexible, efficient and cost-effective form of large scale energy storage system. Here, a mixture of 60% sodium nitrate and 40% potassium nitrate stores energy at over 55 degree Celsius temperature in a hot molten storage tank. When electricity is needed, the hot salt is pumped to conventional steam generator the produce

superheated steam which runs the turbine-generator set and generates electricity.

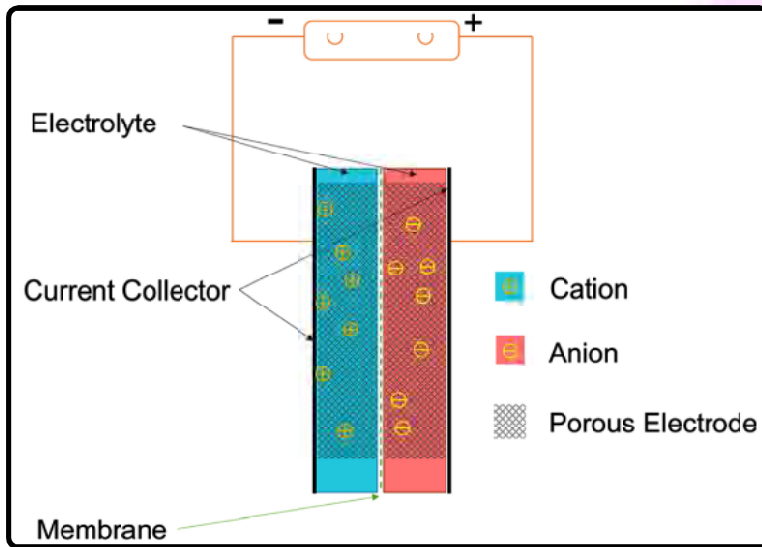
Molten salt energy storage system enables solar thermal power plants to generate electricity.

8. Super Capacitor Energy Storage System

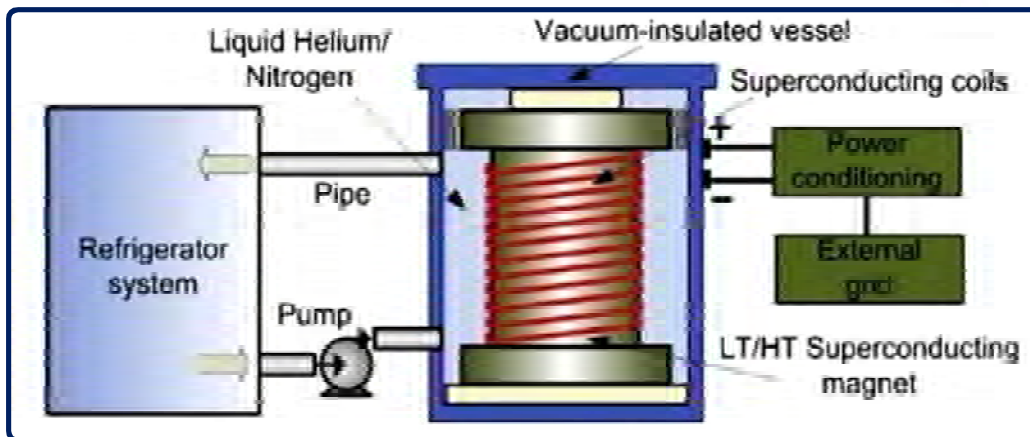
Super capacitor, also called an electric double-layer capacitor or ultra capacitor is a type of high power high energy density capacitor. Here, there are two metal electrodes



Working Principle of Molgen Salt System



Schematic Illustration of a Supercapacitor



Flow Diagram Depicting the Working Principle of SMES

Buses are running on supercapacitors in China, US and some European countries. Trains in Europe use these for short distance running.

9. Superconducting Magnetic Energy Storage System

In the superconducting magnetic energy storage system, energy is stored in a superconducting coil in the form of a magnetic field generated by the current flowing through it. The coil, when cooled below its

superconducting critical temperature has negligible resistance. Niobiumtitanium (NbTi) filaments which has a critical temperature of around 9000 are

usually used to make coils. coated with carbon and separated by a thin porous insulator all in an electrolyte. Energy is stored as electrical energy and is given off as such, without any time gap or energy conversion.

Supercapacitors perform various functions in automobiles like vehicle starting, jump start and cold start, power steering, window operation, regenerative braking and so on. Railways use them for recovering of kinetic energy from decelerating train and reusing the same for accelerating units.

usually used to make coils.

Conclusion

Many of the technologies described here have huge capital costs. Research and development is going on for their cost reduction so that they can be economically used. With development of technology, it will revolutionise our future energy infrastructure.



Plot No. 70, Laxmi Vihar Phase – 1
Bhubaneswar – 751018
Phone : 9438693724

GENERATIVE MACHINE LEARNING

11

Dr. Sourav Mishra

Generative Machine Learning is a subset of algorithms in the field of artificial intelligence that focuses on the creation of new data instances that resemble training data. This is opposed to discriminative models, which are used to classify data. Generative models are powerful tools that can learn the underlying structure of the given data and generate new instances that could pass for real data. Some well-known examples of generative models include Generative Adversarial Networks (GANs), Variational Autoencoders

(VAEs), and certain types of Recurrent Neural Networks (RNNs).

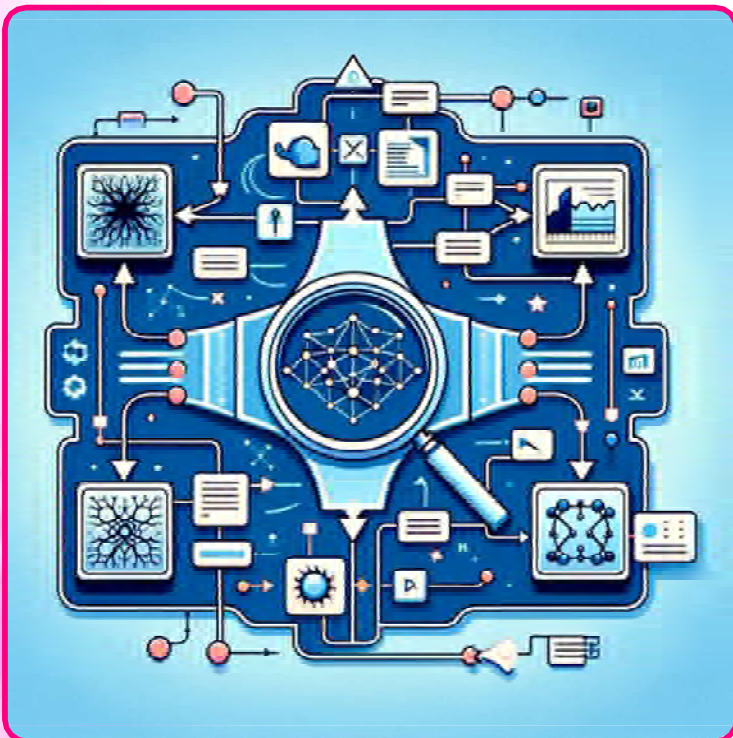
Rise of generative methods: A short primer

The rise in popularity of generative machine learning can be attributed to several factors:

Technological Advances: Significant improvements in computational power, notably through GPUs, have made it feasible to train complex generative models like GANs, which were previously too computationally intensive.

Data Availability: The abundance of data in the digital age provides the necessary fuel for training generative models. More data allows these models to learn more detailed and nuanced patterns, leading to more realistic outputs.

Research Progress: There has been considerable progress in the underlying algorithms and techniques for generative models. Innovations in neural network architectures, training procedures, and regularization techniques have dramatically improved the performance of these models.



Versatility and Creativity: Generative models have a wide range of applications, from creating art and music to generating synthetic data for training other machine learning models. This versatility has sparked the imagination and interest of both the research community and the public.

Practical Applications: In industry, generative models are being applied in areas such as drug discovery, material science, and predictive maintenance, where they can simulate new molecular structures, materials, or system behaviors.

Synthetic Data Generation: Generative models can create labeled, synthetic datasets that can be used to train other models, particularly in domains where data collection is challenging or privacy concerns restrict the use of real data.

Bridging the Gap Between Theory and Practice: Generative models help in understanding and visualizing how deep learning algorithms interpret and process information, bridging the gap between abstract mathematical concepts and practical, tangible outputs.

Entertainment and Media: The ability to create realistic images, videos, and voices has enormous potential in entertainment and media, sparking both excitement and ethical debates, which in turn fuel public interest and awareness.

Anonymization: Generative models can be used to anonymize data, enabling researchers to share and collaborate without compromising individual privacy.

Societal Impact: As society becomes more

digitized, the implications of AI and machine learning grow more significant. Generative models, due to their ability to create convincing fake content, have drawn a lot of attention to the need for ethical AI practices.

The combination of these factors has made generative machine learning a hot topic in both academic research and industry applications, propelling it into the spotlight of the AI field.

Generative Machine Learning Types

Let us try understanding the various types of models, which are being used in generative modeling nowadays:

■ Generative Adversarial Networks (GANs)

GANs consist of two neural networks, termed the generator and the discriminator, which are trained simultaneously through a competitive process. The generator creates data, while the discriminator evaluates it; through their interaction, the generator learns to produce more and more realistic data.

■ Variational Autoencoders (VAEs)

VAEs are also generative models that focus on encoding input data into a compressed representation and then reconstructing the input data from this representation, aiming to capture the probabilistic distribution of the input data.

■ Recurrent Neural Networks (RNNs)

RNNs can be used as generative models when they are used to predict the next item in a sequence, making them suitable for time-series prediction, text generation, and even

music composition.

Risks

■ Misuse

The potential for creating realistic fake content, such as deepfakes, poses significant ethical and security risks.

■ Bias

Generative models can inherit and amplify biases present in the training data, leading to unfair or prejudiced outcomes.

■ Quality Control

Ensuring the quality and accuracy of generated data is a challenge, as generative models can sometimes produce nonsensical outputs that may not be immediately evident.

Future Development

■ Improved Algorithms

Research is constantly being conducted to improve the algorithms behind generative models, aiming to make them more efficient, capable, and able to generate higher-quality outputs.

■ Regulation and Ethics

As the technology advances, so too must the discussions and policies around the ethical use of generative models, especially in areas like media, communication, and law.

■ Applications

The future may see increased use of generative models in fields such as medicine for drug discovery, in entertainment for content creation, and in academia for research assistance.

Conclusion

Generative Machine Learning represents one of the most exciting frontiers in artificial intelligence. While it offers immense potential for innovation, it also brings forth challenges that must be addressed to ensure the technology benefits society as a whole. The future development of generative models holds promise for a wide range of applications, but it is essential that these advancements are guided by careful thought on their implications and uses.



Senior ML Engineer,
AState Inc., Tokyo,
Japan

Machine Learning Applications in Industry

Predictive maintenance: predict failures and anomalies on machinery with the aim of managing efficient maintenance, with an important return in terms of cost reduction.

Sales forecast: predict future sales levels in order to optimize the production process.

Product quality control: check the product quality by detecting production defects.

Forecast of energy consumption: forecast future energy consumption, with advantages both for those who use it and who also supplies it.

- Editor

HARNESSING TERRESTRIAL PLASMA - A BOON TO MANKIND

12



Dr. Gourishankar Sahoo

Plasma – assembly of charge particle constitutes 99% of the visible universe. Even for a theoretical plasma physicist, plasma is an abstraction without a persona. And, for an experimentalist, each plasma has an identity, blood and bone and character. Astrophysical plasma is distinctly different from terrestrial plasma!

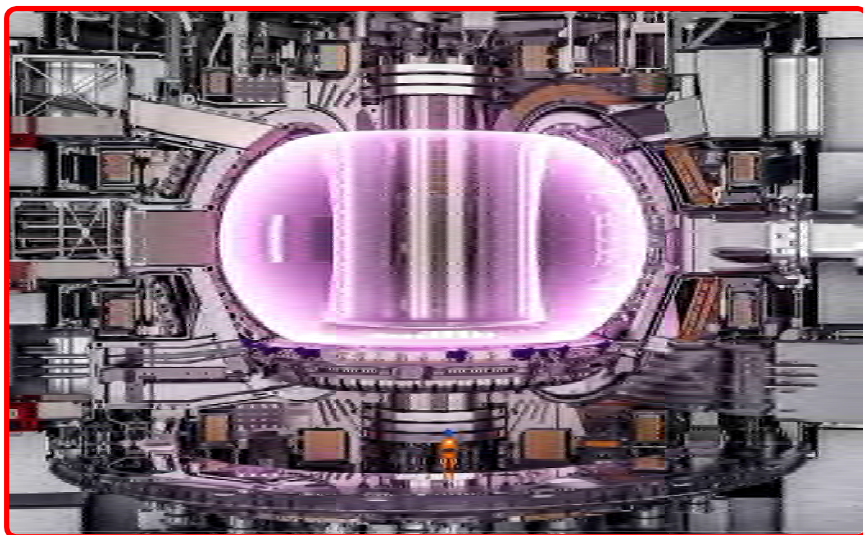
It is worth noting that when solid is supplied with thermal energy it usually become liquid. When liquid is heated up it usually comes to gaseous phase. When gas is heated, what happens? The gas molecule is ionised and we have plasma, assembly of positively charged particles/ions, negatively charged

particle and obviously sometimes neutrals, which is not ionised in due course of time. So, plasma is called fourth state of matter. Strange, we know a little about it !

Plasma is star stuff. A plasma globule which we could keep in our mini-temple at home can be imagined as a sample of the Sun (*Surya Devata*) at home.

Plasma is believed to be clean and green form of energy. Hence, from industry to government research establishment, plasma physics research is in focus for the last few decades. The largest fusion experiment of the world, ITER (International Thermo-nuclear

Experimental Reactor), popularly called the way to new energy is an international collaboration of seven important political powers of the world – United States, Russia, European Union, Bharat, Japan, China and Korea. The experimental set up extends to kilometres in the southern France and costs billions of dollars. The aim is



International Thermo-nuclear Experimental Reactor (ITER)

to create a mini Sun on earth and there by ;

1. Achieve deuterium-tritium plasma in which the fusion conditions are sustained mostly by internal fusion heating
2. Generate 500 MW of fusion power in its plasma
3. Test tritium breeding in a real fusion environment

This is a long journey and Padma Shri. P. I. John aptly remarked:

*“Pinches, mirrors, torii, traps so diverse,
pellets of ice to be lit by lasers;
fusion in bubbles and alchemist’s jars
chasing the dreams that remind you of
stars”.*

Indian fusion device, ADITYA tokamak was born in 1989. The heart of the tokamak was the Ohmic Transformer, an Inductive Energy Storage system that stores magnetic energy. The disruption of the inductor current provides the high voltage pulse necessary to create the toroidal voltage loop to produce the

plasma and drive a high plasma current. We built a multistage capacitor bank to energize the Ohmic transformer. A combination of capacitors charged to different voltages is switched sequentially with ignitrons to realize an initial high loop voltage surge followed by a lower sustaining loop voltage. In the International Conference in Plasma Physics, held in Delhi in 1989, it was declared that ADITYA will be operational after a seven-year effort and now it is operational and the Group Leader now is Prof. Joydeep Ghosh.

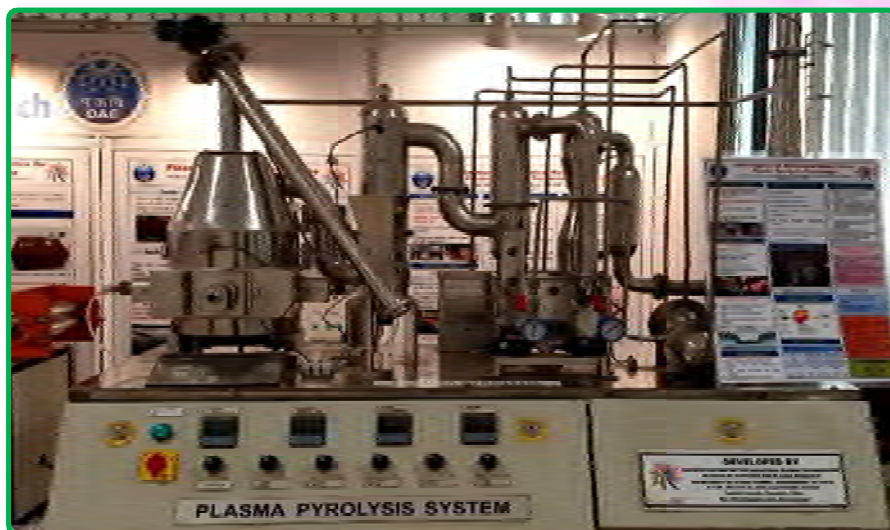
Besides, a numbers of industrial plasma applications are in force.

Plasma pyrolysis technology is one of the many societally beneficial applications developed by FCIPT, Gandhinagar, Gujarat. An international scandal involving a vast intra-European traffic in medical waste originating from France and culminating in eventual redistribution in other European markets in the late 1980s led to the resignation of the then French minister of health. As a result, the world was shocked into recognising the magnitude of the medical waste disposal problem.

India is no stranger to such horror stories. Recycled syringes and quilts packed with used surgical cotton have a thriving market. In 1991, Pioneer reported a well-knit racket operating from the backyards of the All India Institute of Medical Sciences in Delhi transporting syringes to Meerut. Pathogens of deadly diseases like hepatitis B find a ready and fertile breeding ground in the piles of undisposed medical waste.



ADITYA tokamak



Public concern over disposal and treatment of medical waste has resulted in increased regulations and court actions on a global scale. The fundamental reason is the phenomenal growth in the quantity of medical waste generated in the hospitals, attributed to the growing use of disposable as precautions against exposure to infectious diseases such as AIDS and the growth of medical and public health facilities. The generators include hospitals, clinics, and medical research facilities. A rule of thumb for medical waste production in affluent countries seems to be 1 kg per bed per 8-hour shift.

Historically, landfilling was the most preferred means of disposal of medical waste. However, public opposition and positive correlation with groundwater contamination have resulted in this option steadily going out of favour. Burning the waste material in the open air can never be complete, with small quantities of many organic and chlorinated organic compounds and pathogens surviving and leading to dispersal of dangerous diseases

that can spread through the air. Incineration is another method.

With dramatic developments in high-temperature plasma sources, one can apply plasma heat to highly toxic waste, and the final products can be harmless gases. The large flux of ultraviolet radiation in thermal plasma can dehydrogenate organic chlorine. The reactors can process gaseous, liquid, and solid materials.

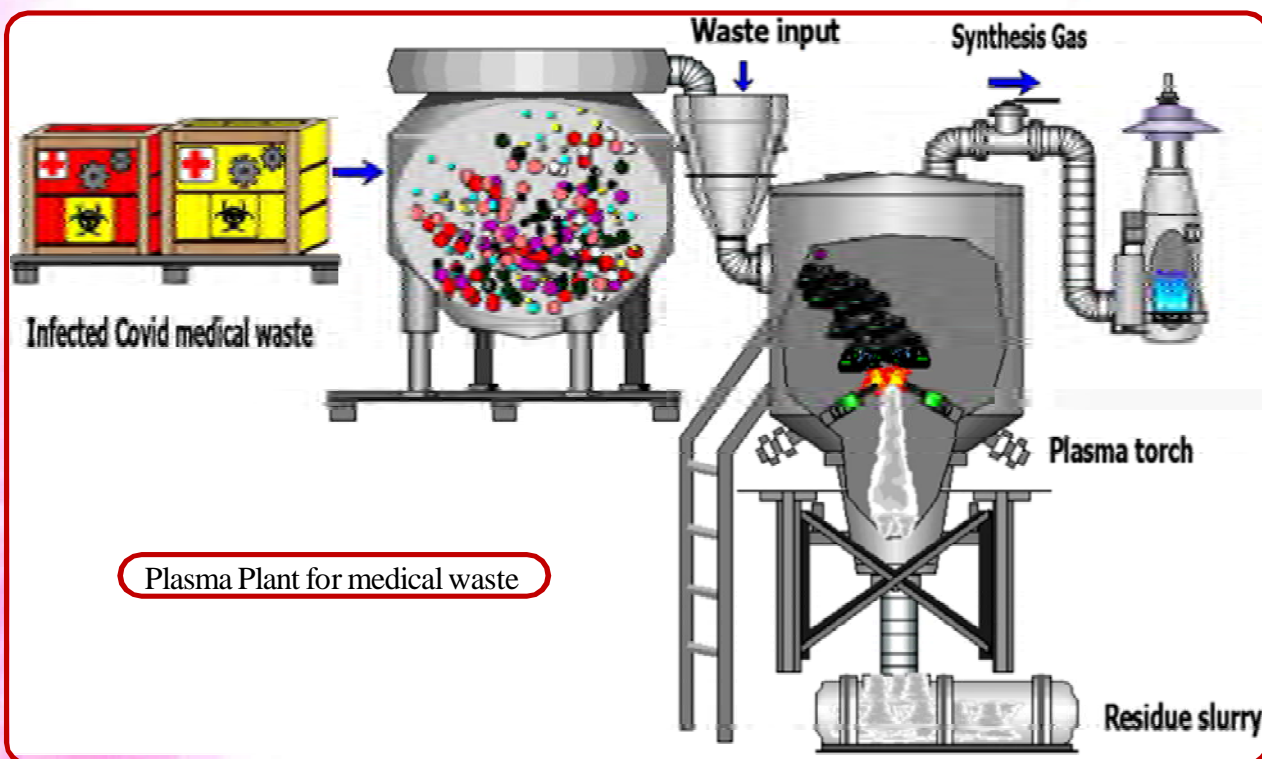
The workhorse of plasma-based waste destruction technology is the plasma torch. Plasma torches are electrical discharge plasma sources with the plasma extracted as a jet through an opening in the electrode and out of the confines of the cathode-anode space. The arc column's inherent thermal and electromagnetic instabilities are stabilised by forced gas flow along the current path. Interaction with a guiding wall or external magnetic fields also stabilises the plasma. DC arc, RF and microwave plasma sources can be converted into plasma torches. Plasma temperatures can easily reach tens of thousands of degrees, and high enthalpy gas flows get generated in large volumes. Pyrolysis is the thermal disintegration of carbonaceous material into fragments of compounds in an oxygen-starved environment. The presence of charged and excited species renders the plasma environment highly reactive, catalysing homogeneous and heterogeneous chemical

reactions. The most likely compounds to form are methane, carbon monoxide, hydrogen, carbon dioxide, and water when the process is optimised. The high temperature and high enthalpy inhibit the formation of hydrocarbons. Hence, plasma torch can be used for pyrolysis and thereby gasification of medical as well as other toxic materials. The product gas is high in hydrogen and carbon monoxide, with traces of methane, acetylene, and ethylene; therefore, it can be combusted very efficiently, resulting in carbon dioxide, nitrogen and water vapour being the only gaseous exhaust to the atmosphere. Emission and leachate results demonstrate convincingly that plasma gasification is a far more environment friendly method of disposing of waste than any competing technology. Plasma gasification provides more than a 95% volume reduction ratio of slag to input material. Other

technologies offer an 80% reduction typically.

The prototype plant was first installed at the Gujarat Cancer Research Hospital for field trials and then a commercial version of a Plasma Reactor came after a series of prototypes built to improve the system's reliability. Gazette notification in 2016 endorsing Plasma Pyrolysis for medical waste destruction is now in force. In the Goa Medical College, plasma pyrolysis plant was installed in 2000 by late Shri Manohar Parrikar, the then Chief Minister of Goa. The engineering of plasma torch and physics associated with it is now primary attraction for researchers to make it low cost, so that it could be widely used.

Plasma nitriding is another important industrial innovation. Nitriding is a process in which Nitrogen is incorporated into the steel matrix to increase hardness. The prototype was



a cold wall furnace with only plasma heating. We added heat shields to minimize heat loss and increase thermal efficiency and uniformity. Plasma Nitriding is one of the important technology now transferred to industry by DAE institute/s. Nitriding of high-value components like plastic dyes etc., on a commercial basis is now in use. Work on many other applications like thermal plasma processing of zircon sands, anodic vacuum arcs, plasma ion implantation etc., followed this.

Following uses of industrial plasma are also worth mentioning:

1. Nitride industrial components like precision moulds and hydro turbine parts, reaching defined hardness and case depth values.
2. Synthesize large-area optical quality reflective and anti-reflective coatings using Plasma Enhanced Chemical Vapour Deposition.
3. Deposit super-hydrophobic fluorocarbon films on surfaces with expanding plasma jets, making them slide without friction.
4. Create high enthalpy flows to test material properties at high temperatures and ignite coal fired furnaces.
5. Densify, spherodize or segregate ceramics in in-flight high-temperature plasma jet reactors and produce aerosols and Nano particles.
6. Texture Angora wool in atmospheric



Angora wool

pressure cold plasma to enhance the spinnability of the yarn.

7. Destroy medical waste with a 95% volume reduction and undetectable levels of dioxins.
8. Create cold plasma streams to induce changes in biological materials with applications in medicine and agriculture.

An atmospheric pressure dielectric barrier discharge system produces large-area Helium-free cold plasma. As a result, continuous streams of Angora wool fibre can be introduced and retrieved after treatment. A technology demonstration unit for Angora wool farmers has been functioning at Kulu in collaboration with the Wool Research Board and the Government of Himachal Pradesh. This research can be the foundation stone to guide future research in this field and thereby improve quality of other fibres and thereby help Indian cotton, wool and silk industry.

Another development relevant to the brassware industry in India is a Technology

Demonstration Plasma Polymerization reactor in which plasma dissociates a monomer containing silicon to form thin silicon dioxide coatings on finished brassware, providing a tarnish-proof lifetime protective coating. The brass ware manufacturers in Moradabad are using the unit for the final finishing treatment of their products. Recently developed plasma treatment process of tyre valve stems made of brass to release Zinc, which interacts with Sulphur in vulcanized rubber to form brass-rubber solid bonds. This durable rubber-brass bond has a high resistance to dynamic and thermal ageing, typical in its use in automobile and truck tyres. Indian scientists scaled up the process to treat more than 600 pieces per batch, necessary for industrial-scale exploitation by a manufacturer of these valves. In addition, this process is environment friendly compared to the conventional treatment, which uses chemicals and acids for the procedure.

Plasma processing has transcended conventional material processing applications into waste destruction, environmental remediation, water purification, flue gas treatment etc. It is emerging as an enabling tool with a broad spectrum of applications relevant to modern industrial society.

A cold plasma system to treat high-density polyethylene (HDPE) has been developed for Central Institute of Plastic Engineering and Technology, Ahmedabad for inline processing of HDPE. Inline plasma treatment facility to treat synthetic textiles

with plasma at the rate of 30 to 40 metres per minute has been supplied to Man-Made Textile Research Association (MANTRA) for innovation in the textile manufacturing process. We have developed an atmospheric pressure plasma system for food processing with continuous feeding of the food material. Nano-powder production technology has been transferred to private industry. A plasma pyrolysis / Gasification system to dispose of the liquid solvent waste and generate useful fuel gas has been installed at CSIR-CSMCRI, Bhavnagar.

In the third conference on “Physics and Industrial Development: Bridging the Gap” at Durban, South Africa Indian scientists initiative in establishing links with the Indian industry for developing and commercializing advanced plasma-based industrial technologies gathered high acclaim and accolades.

Plasma research demands the multi-disciplinary team of scientists, academics, students and industry representatives. Hence, it can create ample employment for Indian youths and solve many challenging scientific as well as environmental issues.

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Department of Physics & Astronomical Science,
Central University of Himachal Pradesh,
Dharmashala, HP

ARTIFICIAL INTELLIGENCE: BEGINNING OF A NEW AGE

13



Srikumar Patel

Artificial intelligence (AI) has emerged as a transformative force, revolutionizing industries, reshaping human interactions, and redefining the boundaries of what is technologically feasible. This comprehensive overview delves into the intricacies of AI, exploring its fundamental concepts, applications, and future implications.

Defining Artificial Intelligence

Artificial intelligence encompasses a broad spectrum of methodologies and techniques aimed at replicating human intelligence in machines.

AI systems exhibit the ability to learn, reason, problem-solve, and adapt, enabling them to perform tasks that typically require human cognition.

The core principles underlying AI include:

- ◆ **Machine Learning:** AI algorithms learn from data, identifying patterns and relationships to make predictions

or decisions.

- ◆ **Deep Learning:** A subset of machine learning, deep learning utilizes artificial neural networks, inspired by the human brain, to process and analyze complex data.



- ◆ **Natural Language Processing (NLP):** AI systems equipped with NLP can understand, interpret, and generate human language.
- ◆ **Computer Vision:** AI algorithms can extract meaningful information from images and videos, enabling tasks like object detection, facial recognition, and scene understanding.

Applications of Artificial Intelligence

AI's reach permeates various industries and aspects of human life, including:

- **Healthcare:** AI aids in medical diagnosis, drug discovery, personalized treatment plans, and robotic surgery.

- **Finance:** AI algorithms analyze financial data for risk assessment, fraud detection, and algorithmic trading.
- **Transportation:** AI powers self-driving cars, traffic optimization systems, and autonomous logistics.
- **Manufacturing:** AI optimizes production processes, automates quality control, and facilitates predictive maintenance.
- **Retail:** AI personalizes customer experiences, enhances product recommendations, and optimizes supply chain management.
- **Education:** AI tailors learning experiences to individual needs, provides



intelligent tutoring, and automates administrative tasks.

- **Entertainment:** AI generates realistic graphics, enhances content creation, and personalizes entertainment recommendations.

The Future of Artificial Intelligence

AI's potential is vast and ever-evolving. Future advancements include:

- ◆ **Artificial General Intelligence (AGI):** The development of AI systems that can perform any intellectual task that a human can.
- ◆ **Augmented Intelligence:** AI will seamlessly integrate with human intelligence, amplifying human capabilities and decision-making.
- ◆ **AI-Powered Automation:** AI will automate routine tasks across industries, enhancing productivity and freeing up human labour for more creative endeavours.
- ◆ **AI-Driven Social Impact:** AI will address global challenges in healthcare, education, environmental sustainability, and poverty alleviation.

Ethical Considerations

The rapid development of AI raises critical ethical concerns, including:

I fear that AI may replace humans altogether. If people design computer viruses, someone will design AI that improves and replicates itself. This will be a new form of life that outperforms humans.

- Stephen William Hawking

- **Algorithmic Bias:** AI systems may perpetuate biases present in the data they are trained on, leading to discriminatory outcomes.
- **AI Transparency:** The decision-making processes of complex AI systems can be opaque, hindering accountability and trust.
- **Job Displacement:** Automation powered by AI may displace certain jobs, necessitating retraining and reskilling programs.
- **Existential Risks:** Unforeseen consequences of advanced AI could pose potential threats to humanity.

Conclusion

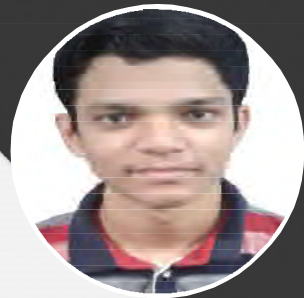
Artificial intelligence stands at the forefront of technological innovation, poised to transform society in profound ways. As AI continues to evolve, it is imperative to harness its power responsibly, mitigating potential risks while maximizing its benefits for the betterment of humanity.



Asst. Teacher
RK Girls' High School,
Dunguripali, Subarnapur, Odisha 767023
Mob No : 700876943
E-mail: nextgenbgh@gmail.com

FUTURE SPACE EXPLORATION

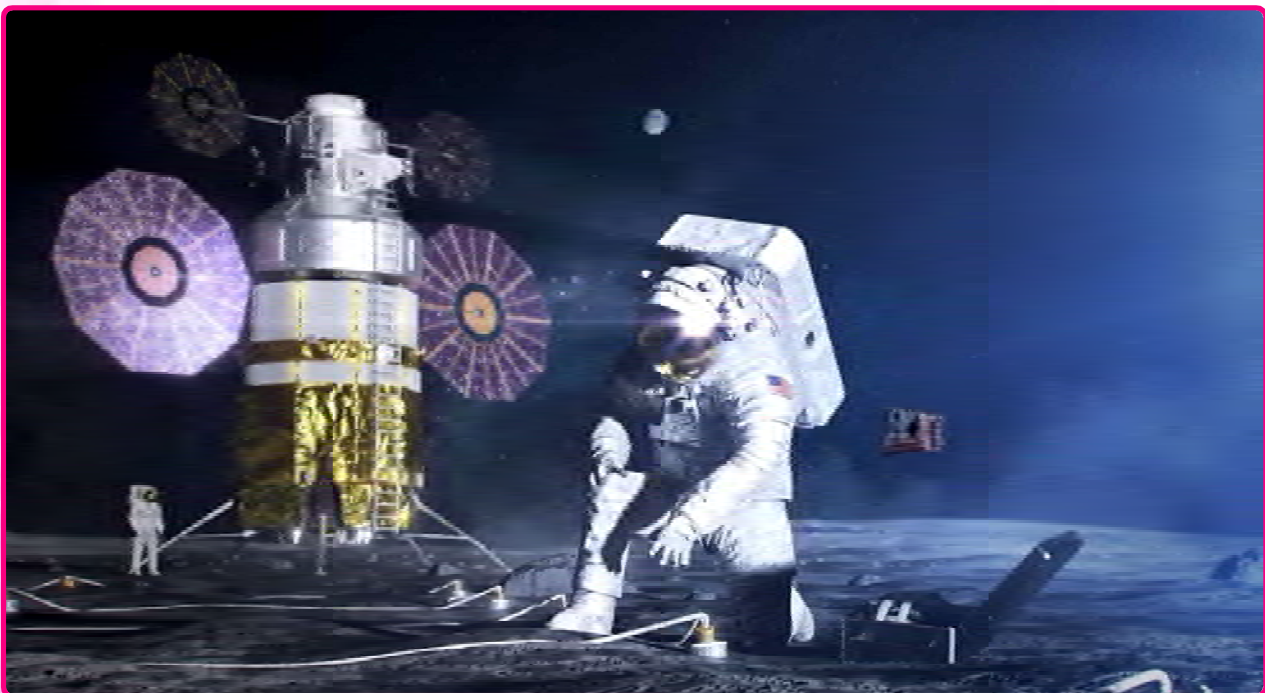
14



Sambit Sagar Panda

For scientists space is first and foremost a magnificent “playground”-an inexhaustible source of knowledge and learning that is assisting in the solution of some of the most fundamental existential issues concerning Earth’s origin and our place in universe. Curiosity has contributed significantly to the evolution of human species. Curiosity along with the desire for a brighter future has driven humans to explore and develop from the discovery of fire by ancient ancestors to present day space explorations.

Space exploration is the use of astronomy and space technology to explore outer space. While astronomers use telescopes to explore space, both uncrewed robotic space missions and human space flight are used to explore it physically. One of the primary sources for space science is space exploration. History of space exploration starts from the launch of Earth’s first artificial satellite, Sputnik-1 on October 4, 1957 by USSR. India launched its first satellite” “Aryabhat” on April 19, 1975 and with the



lunch of international space station space exploration reached another level.

1. Power from Space

Now a days many new technologies are coming which are uplifting the human life in many ways. At present research are going on wireless transmission of solar energy from space. The idea of energy from space was first given by Isaac Asimov in his science fiction short film “Dream” in 1941, which is now moving towards reality, when scientists completed the first transmission of energy from space in Pasadena, California by the California Institute of Technology. Solar power contributes about 3-4% of world’s energy need. But it works only during the day when there is no cloud. In space the sun always shines but the challenge is how to catch enough of its and get it back to earth. If we could do this the possibilities will be endless. It starts with something which is very familiar to us, waves. But, how does it work? Here is the basic idea. You launch a power station piece wise into space and assemble the pieces in the geostationary orbit that is an orbit around equator at about 36 thousand kilometers altitude. An object in such an orbit remains in fixed position relative to the surface without requiring propulsion and it will be in the sunlight for more than 99% of the time. You collect the solar energy up there, convert it into electromagnetic waves and send a beam of that to the ground station. The ground station is basically an array of receiving antennas, or “rectennas” for short. To make sure that the energy wave doesn’t go astray the ground



Space-based Solar Power

station emits a target signal that the space station can aim at. The options that have been proposed for the beam are either a laser or microwaves . Many countries like U.K, U.S.A, China and Japan are working on this project.

2. Space Colonization

Space colony is another area of interest for space scientists and enthusiasts. Imagine a sprawling mega structure floating endlessly through space. One day humans may occupy an orbital settlement several hundred of kilometers from earth. If humans ever migrate into space, what would our settlement look like, and how would we navigate life in final frontier ? A space colony must withstand the harsh conditions of space but also must create a safe and comfortable environment for generations of human colonists. It must have all the essential sources for human life and provide artificial gravity. Space colonists also require protection from solar radiation. The International Space Station which was launched



some 20 years ago, and still revolving around earth with a speed of 28000 km per hour has accommodated several teams of astronauts though they have to take oxygen cylinders, water tanks and food with them. But in a space colony we have to create our own earth-like system by which we can produce our own food, get water and oxygen. This concept was first given by an influential physicist named Gerard O' Neil. His first conceptual space colony features as huge cylinders, which is 32 km long and 6 km in diameter with artificially built earth like ecosystem, which can have thousands of human colonists. He also proposed another habitat called the Bernal sphere.

3. Interstellar Travel

Interstellar travel is the hypothetical travel of spacecraft from one star system, solitary star or planetary system to another. This is more difficult than inter planetary spaceflight due to the vast difference in the scale of involved distances. As of 2023, five uncrewed space crafts, launched and operated by U.S. have achieved the escape velocity required to leave the solar system as part of missions to explore parts of outer solar system. However, they will not approach another star of thousands of years, long after they have ceased to operate. This is in initial stage of experiment and we have to go a long way in this field.

4. Asteroid Mining

Asteroid are millions of trillions of rocks, metal and ice leftovers from the clouds

that became the planet 4.5 billion years ago. They can be small or as large as an entire country. As space travel is becoming more feasible scientists have been looking at the resources found in these asteroids. Even relatively small metal asteroid may contain trillions worth of industrial and precious metal like platinum and bigger asteroids like 16 Psyche could contain enough iron and nickel to fulfill our demand for millions of years.

5. Space Elevator

Space elevator, is also a new inspiration for space scientists and enthusiasts. It is also called as space ladder, space bridge or orbital lift. It is a proposed type of planet to space transportation system, often seen in science fiction. The concept of space elevator was first published in 1895 by Konstantin Tsiolkovsky. His proposal was for a free standing tower reaching from the surface of earth to the height of geostationary orbit.

There are two sides to every coin. To survive on Earth, one must confront and overcome obstacles. Space exploration is an essential activity that can not be overlooked, but it can be enhanced by technological development. Recently our Prime Minister Narendra Modi has declared that India is going to make its own space station by 2035 and will send Indians to Moon by 2040. Best of luck to our scientists for these missions.



At/Po: Mugagahir,
Ps: Baramba, Cuttack-754031
Mob: 9178330785

NEW GENERATION ANIMAL HUSBANDRY



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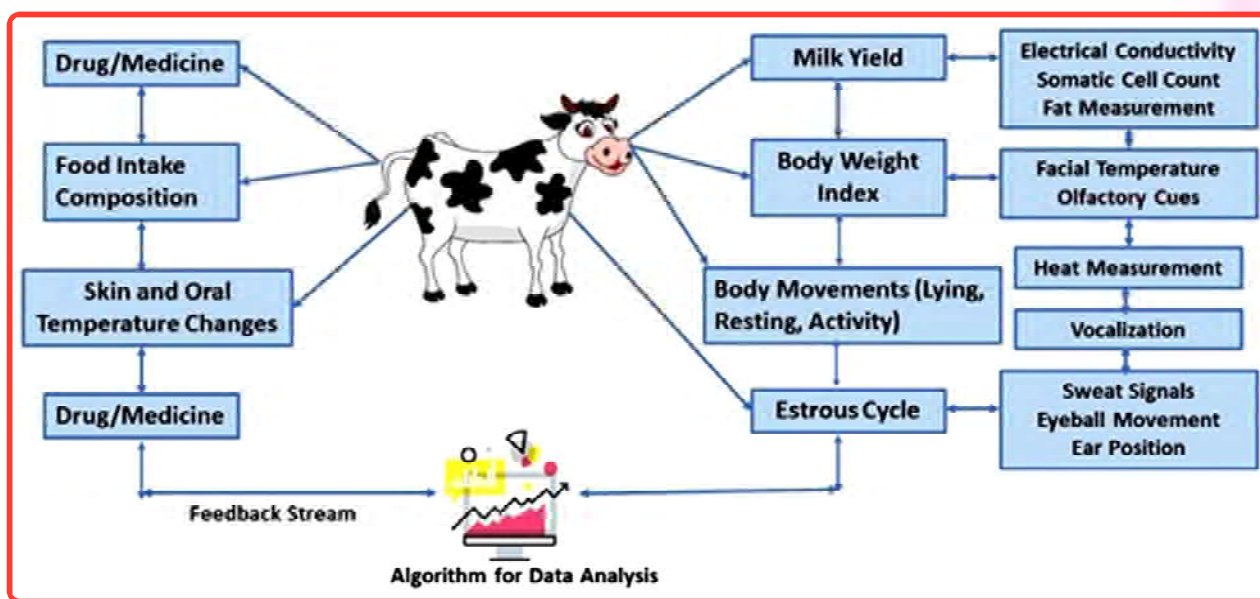
¹Dr. Debendra Nath Biswal
²Dr. Shabnam Akhtar

In India Animal Husbandry(AH) contribution is very significant now a days . It serves many uses for human beings. It also helps in proper management of agricultural wastes. Livestock contribute 6.2 percent to Gross Value Added (GVA) to national GVA and 31% to agricultural GVA. Animal husbandry helps in the proper management of animals by providing proper food, shelter and protection against diseases to domestic animals. It provides employment to a large number of farmers and thereby increases their living standards. It helps in developing high yielding breeds of animals by cross breeding.

Livestock Entrepreneurs and farmers have aims to produce animals with high yielding quality, to produce animals with high feed conversion rate to produce animals with high growth rate and early maturity and also to produce animals that can adapt to varied climatic conditions. Hence Future Generation AH badly needs Artificial Intelligence (AI) use in Modern Scientific Profitable Livestock Farming.

Artificial Intelligence(AI) in animal husbandry

AI in animal health/animal husbandry



Application of AI in Animal Husbandry

refers to the application of artificial intelligence technologies, such as machine learning and computer vision, in the veterinary industry. It involves the use of algorithms and data analysis to improve disease diagnosis, treatment planning, and overall animal care.

AI also helps farmers collect and analyze large volumes of data from various sources, such as sensors, wearable devices, and cameras. By analyzing this data, AI systems can provide insights into factors like animal behavior, health conditions, feeding patterns, and environmental conditions.

Role of Artificial Intelligence(AI) in Veterinary Science

The application of AI has revolutionised the veterinary field by solving some of the most pressing problems that the animal sector faces daily. AI and machine-learning algorithms are now being utilised to benefit modern animal husbandry and animal farming. They help in identifying animals of different weights and stages, feed differently, and improve the output rate of high-quality feeding animals. AI in animal husbandry is used for raising animals for meat, fiber, milk, eggs, and other products. With AI, providing day-to-day care and raising livestock have become easier for animal farmers. For example, farmers are making use of wearable AI devices to collect real-time data and receive important alerts about them to make necessary decisions, such as when their animals are sick, when they should be vaccinated, or when it is time for insemination. The scientific research involving AI models and sensors, especially in animal farming, is

focused on data collection, processing, assessment, and analysis in the fields of estimation of growth and behaviour detection, disease and environmental monitoring, etc., mostly on farm animal species such as pigs, cattle, and poultry. The specific applications of AI in the field of veterinary science and animal husbandry are as follows:

AI for Health Monitoring and Disease Detection/Control

AI-powered image analysis system is a technique for monitoring the health of farm animals and dairy cattle with a high degree of accuracy. It provides for detailed observation and enables early detection of injuries and symptoms of disease or illness that could impact the overall health and quantity or quality of milk production, especially in dairy animals. The AI system is also being used to recognize the facial expressions to detect if an animal is in pain or distress, to detect decreased growth of an animal, and even to do repetitive work in an animal farm. For example, in a poultry farm, feeding birds, collecting, counting, and packaging eggs, and removing manure can be completely automated using robots, etc. Modern dairy farms use a robotic injection system to deliver vaccines and reproductive medicines to domestic animals. The system reads the tags attached to the animal's ear and gets health-related information and a vaccination record. If the animal needs an injection, it is directed to the injection site, and the injection mechanism positions itself to deliver the medication. Thus, the use of advanced AI and machine learning algorithms



How AI is Reinventing Animal Husbandry



enables a farmer to keep an attentive eye on the herd, thereby identifying, predicting, and preventing disease outbreaks. Use AI of Drones for health monitoring of animals for better production and management with less labour cost.

AI in Animal Production

The occurrence of the oestrus cycle results in the release of specific hormones that affect the animal's behaviour and movement. Thus, the AI components of the dairy automation system process the collected data to provide insights on heat stress, changes

in feeding efficiency, the oestrus of the individual animal, and time for insemination and calving.

AI in Milk Production/ Automated Milking

With AI-enabled smart sensors, the automated milking units can analyse the milk quality and flag for abnormalities in the product. In addition, the milk production level of an individual dairy animal can be assessed and recorded. AI systems can also monitor the environmental conditions (e.g., temperature, humidity etc.) of a shed and adjust accordingly. In poultry farming, AI can differentiate between fertile and infertile eggs by scanning the eggs, and then algorithms can be created that can determine the accuracy of fertility in the early stage of incubation. AI monitoring systems that allow artificial environmental

changes with voice commands is useful in case of growing insects like crickets and in detection of perfect breeding time. Even sensors can be incorporated into beehives to monitor hive weight, temperature, and humidity as well as to track the sound waves produced by a swarm of bees.

AI in The Improvement of Feed Quality, Feed Efficiency and Intake

The use of robotics speeds up the harvesting time, when compared to traditional harvesting methods. Moreover, the automated machinery calculates moisture levels in the



cereals harvest as well as overall yield, measures feed intake for individual animals and optimizes feed expenses according to the animal's needs. Technology can help in accurate estimation of performance of farm animals such as by assessing the energy expenditure during lactation based on parity, milk yield component, and body condition score.

AI initiatives in Government

In addition to the utilisation of AI in the animal sector, the Government of India has initiated the idea of digitalizing the agricultural system throughout the country. Some of the steps taken forward in this matter are:- Initiation of the Digital Agriculture Mission (2021–2025) in association with CISCO, Ninjacart, Jio Platforms Limited, ITC Limited, and NCDEX e-Markets Limited (NeML) through pilot projects based on AI technologies, block chain, remote sensing, GIS technology, etc. Promotion of several digital apps to boost adoption of AI technologies, such as the National Agriculture Market (eNAM), launched in April 2016, and the Direct Benefit Transfer (DBT) Central Agri Portal, launched in January 2013.

Artificial Intelligence (AI) technologies have the potential to provide valuable insights

into biodiversity changes, detect and attribute causes to those changes, and help prioritize and plan conservation local breeds of livestock for profitable AH efforts. AI can be used in healthcare to detect diseases earlier than humans can, such as skin lesions, lung nodules, heart murmurs, or voice changes. It can also analyze genetic, environmental, and lifestyle data to assess the risk of developing certain diseases. The most important attribute of AI is to provide a significant boost towards combating global hunger. Its presence in improving agriculture, animal husbandry, fisheries, food, storage and distribution processes and the way to intelligently deal with weather can create a crucial advantage, beneficial to all. As a matter of fact, Artificial Intelligence is still at a very nascent stage and a lot remains to be unravelled. Apart from the setbacks of AI such as cost, development and implementation issues, it is projected that eventually AI will improve the effectiveness, access, and affordability of welfare of animal and society at large.



Faculty,
Institute of Veterinary Science & Animal Husbandry
Siksha 'O' Anusandhan University, Bhubaneswar

I think the biggest innovations of the 21st Century will be at the intersection of biology and technology. A new era is beginning.

- Steve Jobs

VISIONS FOR FUTURE TECHNOLOGIES

16



Sashibhusan Rath

According to Albert Einstein, ‘If at first an idea does not sound absurd, there is no hope for it’. Our most far-fetched ideas today are destined to become tomorrow’s reality. Looking at science and technology just around the corner, may have the cue to the future. Any projection into the future, in the areas of invention, will have both fiction and facts. Thought experiments will be of crucial significance to pinpoint ‘provable’ from ‘probable’ for technological progress

AI (Artificial Intelligence)

It is the intelligence of machines or software, as opposed to the intelligence of humans or animals. AI is widely used throughout industry, government and science. Some high-profile applications are: advanced web search engines (e.g. Google search), recommendation systems (used by YouTube, Amazon and Netflix etc), understanding and responding to human speech (such as Siri and Alexa), auto-driven driverless cars (e.g. Waymo), creative tools (ChatGPT and AI art), and competing at the highest level in strategic games such as chess, war, counter-intelligence etc.

Artificial intelligence was founded as an academic discipline in 1956. The field went

through multiple cycles of optimism followed by disappointment and loss of funding, but after 2012, when deep learning surpassed all previous AI techniques, there was a vast increase in funding and interest.

Today AI research has entered exclusive human areas of reasoning, knowledge, representation, planning, learning, natural language processing, perception. Tomorrow it will cover all areas of human interest and imagination.

General intelligence (the ability to solve an arbitrary and common problem) is one of the challenges ahead in AI. To solve these problems, AI researchers have adapted and integrated a wide range of problem-solving techniques, including multi disciplines like mathematics, statistics, optimisation, operations research, neural networks, psychology, economics, philosophy, linguistics etc.

John McCarthy coined the word AI, and his associates were Alan Turing, Marvin Minsky, Allen Newell, Herbert A. Until now it is limited to four types: reactive, limited memory, mind and existential but soon it will cover other aspects.



AH(Antimatter Harvest)

Antimatter has long been the focus of intense speculation. Although an antimatter bomb does not exist, physicists have been able to use their powerful atom smashers to create minute quantities of anti-matter for study.

We know that when matter and antimatter touch each other the result is a monumental explosion, many times more powerful than a hydrogen bomb. Although an antimatter bomb is pure fiction, antimatter is very real.

Andrei Sakharov, the man who designed the hydrogen bomb for the Soviet Union in the 1950s, theorised that at the beginning of the universe there was a slight asymmetry in the amount of matter and antimatter in the big bang origin of the universe.

This tiny ‘symmetry breaking’ is called “CP violation.”

This phenomenon is currently the centre of much vigorous research. In effect, Sakharov theorised that all the atoms in the universe today are only left over from a ‘near perfect cancellation’ between matter and antimatter. The tiny leftover matter created a residue that forms the visible universe of today. All the atoms in our bodies are leftovers from this titanic collision of matter and antimatter.

CP stands for charge conjugation (C) and Parity(P). This violation is responsible for radioactivity decay in atomic nuclei. It explains dominance of matter over antimatter, therefore holds the key to further study in antimatter and its possible use in harnessing tremendous amounts of energy.

This idea opens the possibility that small amounts of antimatter may occur naturally. If so, discovering that source would drastically reduce the cost of producing antimatter for use in antimatter engines. In principle, deposits of naturally occurring antimatter should be easy to detect. When an electron and an antielectron meet, they annihilate into gamma rays at an energy of 1.02 million electron volts or more. Thus by scanning the universe for gamma rays at this energy one could find the “fingerprint” for naturally occurring antimatter.

In fact, “fountains” of antimatter have been found in the Milky Way galaxy, not far from the galactic centre, by Dr. William Purcell of Northwestern University. Apparently a stream of antimatter exists that creates this characteristic gamma radiation at 1.02 million electron volts as it collides with ordinary hydrogen gas.

If this plume of antimatter exists naturally, then it might be possible that other pockets of antimatter exist in the universe that were not destroyed in the big bang.

To look for naturally occurring antimatter more systematically, the PAMELA (Payload for Antimatter-Matter Exploration and Light-Nuclei Astrophysics) satellite was launched into orbit in 2006. It is a collaborative effort between Russia, Italy, Germany, and Sweden, designed to search for pockets of antimatter.

Gerald Jackson of Hbar Technologies US, estimates that only seventeen grams of antimatter, would be enough to fuel a starship to Alpha Centauri. Jackson claims that there

might be 80 grams of antimatter between the orbits of Venus and Mars that might be harvested by the space probe. Given the complexities and cost of launching this huge antimatter collector, however, it probably won't be realised until the end of this century, or even beyond. Some scientists have even dreamed about harvesting antimatter from meteors floating in outer space.

An atomic bomb, for all its awesome power, is only about 1 percent efficient. Only a tiny fraction of the uranium is turned into energy. But if an antimatter bomb could be constructed, it would convert 100 percent of its mass into energy, making it far more efficient than a nuclear bomb. (More precisely, about 50 percent of the matter in an antimatter bomb would be turned into usable explosive energy; the rest would be carried away in the form of undetectable particles called neutrinos).

If naturally occurring antimatter is not found in space, we will have to wait decades or even centuries before we can produce significantly large quantities of antimatter on the Earth. But assuming that the technical problems of producing antimatter can be solved, this leaves open the possibility that one day antimatter rockets may take us to the stars.

DW (Digital World)

In the twenty-first century, we no longer think of reality as particles and force fields only. Instead, scientists and philosophers view the world as a sea of computation. It continues to give us new ways to understand nature,

society, and the mind. DW reveals hitherto unknown areas before us.

“A journey of a thousand miles begins with one step,” goes the ancient saying. This concept is at the root of the computational worldview, which basically says that very complex systems- the world we live in, have their beginnings in simple mathematical equations.

We've lately come to understand that such an algorithm is only the start of a never-ending story-the real action occurs in the unfolding consequences of the rules. The chip-in-a-box computers so popular in our time have acted as a kind of microscope, letting us see into the secret machinery of the world.

Everything is a computation-that thoughts, computations, and physical processes are all the same. Linguistic and computational advances that make this kind of “digital philosophy” possible, and explains how, like every great new principle, the computational worldview contains the seeds of a next step ahead.

GE (Green Electricity)

Serbian-American inventor Nikola Tesla dreamed of harnessing energy from the air. He ran a series of experiments trying to capture electrical charges from the atmosphere and transform them into an electric current. Since Tesla's time, scientists have learned more about how electricity is formed and released in the atmosphere and discovered that water vapour can carry an electrical charge.



The technique involves harvesting the tiny charges of static electricity contained in gaseous water molecules, which are ubiquitous in the atmosphere. The process is known as hygroelectricity or humidity electricity.

‘With this new renewable-energy source, we believe we will drastically increase the efficiency and the possibilities of the green-energy transition,’ said Lyubchyk, chief executive officer of Portuguese start-up Cascatachuva Lda.

The know-how could be a boost for the EU, which gets about 22% of its energy from renewables. It is on track to tighten an end-of-decade target for such sources, which also include hydropower, to as high as 45%.

As the European Union strives for climate neutrality by mid-century, the potential hurdle caused by the limited number of renewable-energy sources is driving the EU’s shift away from fossil fuels.

Andriy Lyubchyk project aims to expand a clean-energy mix by perfecting the conversion of atmospheric humidity into electricity.

Harnessing and storing electricity from storming lightning is a challenge for scientists. This Green Electricity is step beyond fossil, hydro, nuclear based generation.

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Life Member Indian Physics Association,
Odisha Bigyan Academy
N-1, A/32, IRC Village
Bhubaneswar-751015
Mob: +91 8249544076

Observatory on Moon

Radio telescopes around the world has been established to study on astronomical bodies. In our country the Giant Meterwave Radio Telescope (GMRT) located near Pune is an example. Due to atmospheric and light pollution, these are not as effective as expected. Then telescopes have been put on Earth’s orbit (the latest being James Webb Space Telescope). Although these telescopes give a better view than those on Earth, they have the limitations on size as they have to fit within a certain payload and could be vulnerable in space debris. Some telescopes that observe in the infrared also need cooling fluid. Further, they are hard to access if they need repairs or modifications.

Now scientists have planned to put radio telescope on Moon which will not have the problems of those put on Earth or space. The lunar poles have permanently shadowed regions inside impact craters that could serve as potential sites for a large telescope. These sites also stay cold enough (about -427 degrees Fahrenheit) to allow for infrared observations without needing a coolant.

As of now it seems impossible, but when we will have larger presence on Moon, this may become feasible then.

3D PRINTED FOOD: A FUTURE POSSIBILITY

17



Dr. (Mrs.) Mridula Mishra

Impossible is always a relative term. Something impossible today, may be possible tomorrow or centuries or millions of years into the future due to advancement of understanding of science and technology. The everyday technology which we enjoy today like world-wide communication network resulting in mobiles and smart televisions were surely considered to be magic to our forefathers. The curious human mind with thinking brain and working fingers always tries to explore newer domain and innovate new things. Accordingly, the '3D printed food' is an emerging technological applications of 3D printing.

3D printing or three-dimensional printing, also known as additive manufacturing, is a process of creating three dimensional objects by adding material layer by layer one on top of another. This process is analogous to the fusing of ink onto paper in a printer (hence the term printing). It is the solidifying or binding of a liquid or powder at each spot in the horizontal cross section where solid material is desired. And the layering is repeated hundreds or thousands of times until the entire object has been finished throughout its vertical dimension.

Originally, the term 3D printing designated a specific process patented as 3DP by scientists at the Massachusetts Institute of Technology in 1993 and licensed to several manufacturers. Today the term is used as a generic label for several related processes. Central to all of them is computer-aided design (CAD) software. Using CAD programs, engineers developed a three-dimensional computer model of the object to be built up. Then this model is translated into a series of two-dimensional 'slices' of the object and then into instructions that tell the printer exactly where to solidify the starting material on each successive slice. There are several types of 3D printing technologies like 'Fused deposition modelling', 'Stereolithography', 'Selective laser sintering' etc. Due to technical complexities, the details of these processes will not be discussed here.

Depending on the applications and the capabilities of the specific 3D printer, it uses various materials like plastics, metals, ceramics, and organic materials as food or living cells. Researchers continue to experiment with 3D printing, producing objects as different as automobile bodies, concrete blocks, prosthetics, and medical implants etc.

India's first 3D-printed house had been inaugurated by finance minister Nirmala Sitharaman at IIT Madras campus two years ago. This year(2023) India has inaugurated its first 3D printed public building, a post office in Bengaluru, constructed by L&T company using 3D printing technology at a cost of Rs 23 lakh over 43 days only.

Now, the domain of edible food products is being ventured with 3D printing technology. According to a study published in the journal '*NPJ Science of Food*' recently a group of engineers at Columbia University whipped up a seven-ingredients vegan cheesecake that was assembled and cooked entirely by a 3D-printing machine in a new innovation-laser technology.

The experiment was a step toward developing practical uses for 3D printing in mechanically assembled food. Using 3D printing to prepare food is not entirely a new concept. In fact, in the year 2006 a project led by group of students of Cornell University was the first multi-material 3D printer to print food materials such as chocolate, cookie dough and cheese. Similarly in 2018, another company started using the technology to make plant-based steak. And other temporary restaurants also offer meals produced entirely by 3D printers. What stands out about Columbia Engineering's research is that it



3D Printed Cheesecake

uses lasers to cook the food as it prints. The utilization of lasers may be an important development, because the heat provided can prompt a phase change from paste to solid. This phase change is critical to traditional baking. The effort has evolved into developing a machine that can handle 18 ingredients and print and bake food simultaneously. According to the researchers it works great on the millimeter scale of printing, and one can control it with much higher resolution than with an oven or a stove top. There is also the potential to make foods to a person's preferences.

At the end, it can be said that there is a long way to go before adopting these 3D printing in home kitchens due to price of the machines, acceptable taste of food and applicability in varieties of food preparation.

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Former Associate Prof. in Physics,
B-102, Life Style Green Apartment,
KIIT Square,
Bhubaneswar-24

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The Secretary,
Odisha Bigyan Academy,
Plot No. B/2, Saheed Nagar,
Bhubaneswar - 751 007
Telephone - 0674-2543468
E-Mail - cesh.oba1@gmail.com

website : www.odishabigyanacademy.nic.in
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