Prelim Bits 07-05-2024 | UPSC Daily Current Affairs

Diffusion transformer (DiT)

The new AI model 'Sora' is powered by Diffusion transformer (DiT)

- **Sora** – An AI model developed by OpenAI that process the prompts in natural language and generate minute-long videos in high definition *using diffusion transformer model.*

AI models
• They are essential architecture that have redefined the landscape of machine learning (ML), a subset of AI, applications. • There are 2 models in AI innovation. • **Transformer-based models** – It is used to change a simple picture bit by bit into something you want. • **Diffusion models** – It is essentially the *spreading of particles* from a dense space to a lesser dense area. • It have become the most preferred for AI that generates images.

- **DiT** – Diffusion transformer, is essentially *a class of diffusion models* that are based *on the transformer architecture*.
- **Developed by** – William Peebles at UC Berkeley.
- **Aim** – To improve the performance of diffusion models by switching the commonly used U-Net backbone with a transformer.

U-Net *is an architecture employed in diffusion models for iterative image denoising but it may not provide the best solution all the time.*

- **Principle**
  - **Use concept of diffusion** – For predicting videos
  - **Use the strength of transformers** – For next-level scaling
- **Working** – It make videos by breaking them down into smaller parts, adding a bit of randomness (noises), and then cleaning things up based on the text.
- **Latent diffusion process** – *Noise* is gradually transformed *into the target image* by reversing the diffusion process guided by a transformer network.
- **Diffusion timesteps** – It act like checkpoints and at each checkpoint, DiT looks at the picture and decides to make it better.

Runway's Gen-2 and Google's Lumiere had previously showcased some breathtaking capabilities of video generation that could potentially replace filmmaking in the future.

Reference

The Indian Express| Sora uses Diffusion Transformer AI Model

Magnetic Resonance Imaging (MRI)

An MRI procedure reveals an image of a body part using the hydrogen atoms in that part.

- **MRI** – It is a *non-invasive diagnostic* procedure, used to obtain *images of soft tissues* within the body (tissue that hasn't become harder through calcification).

  Paul Lauterbur and Peter Mansfield refined the MRI machine and were awarded the medicine Nobel Prize in 2003.

- **Principle** – *Using the hydrogen atoms,* which are present almost throughout the body but abundant in fat and water.
- A hydrogen atom spin with axes pointing in random directions but in a magnetic field, its *spin axis* will point along the field's direction.
- **4 essential components** – *Bore*, a hole in the centre, where the person whose body is to be scanned is inserted.
- A *superconducting magnet* inside the bore, which produce a powerful and stable magnetic field around the body.
- A *radiofrequency pulse emitter* and a *detector* to receive the emissions from the atoms present in the scanned part.
- **Working** – The magnetic field is applied, such that the axes of roughly 50% of the Hydrogen atoms are pointing one way and the other 50% are pointing the other way.
- Only a handful remain unmatched — i.e. a *small population of 'excess' atoms pointing one way or the other*.

  

- When the pulse is on, a fraction of excess atoms absorb it and gets excited and return to lower energy state by *emitting radiations* when switched off, this emitted radiation is converted *as images*.

  ***Larmor frequency** is the frequency of pulse the 'excess' atoms have to absorb.*
  ***T1 relaxation time,** the time duration when excited atoms emits energy and return to lower energy states.*

- At times, a contrast agent like *gadolinium-based compound* is injected to the person to improve their visibility in an MRI scan.
- **Application** – In the observation & treatment of certain *cancers* like prostate cancer and to track various *neurological conditions*.
- MRI scans of *changes in blood flow* is used to infer the way the activity of neurons is

changing in the brain.

- **Pros** – It don't pose any threat on the body and it scan portions that are just a few millimetres wide.
- **Cons** – Machines are expensive and so the scan costs.
- The individual is actually expected to lie still for tens of minutes as their movement may distort the images.
- **Challenges** – Since it uses strong magnetic fields, individuals with metallic implants may not be able to undergo MRI scans and its effects on pregnant women aren't as well-studied.

During MRI scan, if the person have a credit card in their pocket, the magnetic fields will wipe its magnetic strip.

Reference

The Hindu| Magnetic Resonance Imaging

Quarks

Scientists have reported that the insides of most massive neutron stars is most likely made of an unusual state of matter called quark matter.

- **Background** – All atoms are made of protons and neutrons inside the nucleus and electrons outside.
- Unlike electrons, *protons and neutrons are composite particles* because they are further *made up of quarks*.
- **Quarks** – They are called strongly interacting particles because they are bound by the strong force.
- **Properties** – They *can't exist in isolation*, even in the vacuum of empty space and can only be found in groups, such clumps of quarks are called ***hadrons.***

Large Hadron Collider (LHC) is the world's largest science experiment.

- Clumps can of heavier quarks or lighter quarks like in protons and neutrons.
- **Rejects conventional particle-physics models** – As 3-quark clumps are more likely to form than 2-quark clumps, the consolidation of quarks is dependent of the particle environment.
- **6 types** – Up, down, top, bottom, strange, and charm and each quark can have one of 3 types of colour charge.
- **Antiquarks** – It is an antimatter versions.
- **Meson** – It is a quark-antiquark clump.
- **Baryons** – They are 3-quark clumps.
- **Gluons** – A set of particles that also held quarks together.
- **Quantum chromodynamics** – A theory that explains how the nuclear force holds

quarks together.

- When lead ions were smashed against each other at very high energies, a state of matter called a *quark-gluon plasma* exists for a brief moment, suggest that the quarks are independent.

According to the Big Bang theory, the universe was filled with this plasma before the particles clumped and formed the first blobs of matter.

Life of a Star
• **The force of gravity** – It arises from the star's mass, encourages the star to collapse under its own weight and implode. • **The nuclear force** – It is released by fusion reactions at its core, pushes the star to blow up and outwards. • **Star shines** - Normally, these 2 forces are equally matched. • **Death of a star** – Once a star runs out of material to fuse, nuclear fusion weakens and gravity starts to gain the upper hand thus the star will 'die' and implode. • **Afterlife of a star** – Depending on its size when it lived, it becomes a white dwarf, a neutron star or a black hole. • **Neutron stars** – It will fuse all protons and electrons inside into neutrons, thus its name. • A research study suggest that insides of most massive neutron stars have an 80-90% chance of being made of quark matter.

Reference

The Hindu| Quarks – A detailed study

ICUBE-Q

Pakistan in collaboration with China launched its first-ever lunar mission iCube-Qamar recently.

- It is a compact lunar cube *remote sensing satellite* that orbit the moon as part of Beijing's Chang'e-6 mission.
- **Developed by –** Pakistan's Institute of Space Technology (IST) in collaboration with Pakistan's national space agency SUPARCO, and China's Shanghai Jiao Tong University (SJTU).
- **Weight –** 7kg.
- **Scientific instruments** – Two optical cameras designed to capture various images of the moon's surface.
- It will enable Pakistan to have its own satellite-based research imagery of the moon.
- **On-board Chang'e 6** – In 2022, the China National Space Administration (CNSA) invited member states via the Asia Pacific Space Cooperation Organization (APSCO) to include a student-built payload on the Chang'e 6 mission.
- Pakistan's ICUBE-Q was chosen for the above mentioned programme.

CubeSats

- They are *diminutive satellites* known for their compact dimensions and uniform design.
- They are built in a cubic form, comprising modular components adhering to precise size limitations.
- **Features** – It typically weigh only a few kilograms and serve various purposes in space exploration, primarily aiding scientific research, technological advancement, and educational endeavours.
- Additionally, they support a broad spectrum of missions such as Earth observation, remote sensing, atmospheric studies, communication, astronomy, and technology testing.

China has ambitious plans for its lunar exploration program, with aims to put astronauts on the moon by 2030.

References

1. Business Standard | 'ICube Qamar' lunar mission
2. The Times of India | iCube-Qamar
3. Firts Post | iCube-Q

Marrakesh Agreement

2024 marks the 30th anniversary of signing of Marrakesh Agreement.

- An agreement that fundamentally reshaped the international trading system by introducing a more robust and comprehensive structure for trade relations.
- **Signed in** – ***1994***, by 123 countries.
- **Shared vision** – To transform the world through trade.
- **Outcome** – Establishment of ***World Trade Organization (WTO)*** **in 1995**.
    - Headquarters - Geneva Switzerland
    - India is a member
- **Achievements** – While the GATT mainly dealt with trade in goods, the WTO and its agreements also cover *trade in services and intellectual property*.
- It has helped to bring about a major *expansion in global trade*, with the objective of raising living standards, increasing employment and promoting sustainable development.
- More than 1.5 billion people have been lifted *out of extreme poverty*.
- The WTO's membership has expanded to 164 members, representing over 98% of international trade.
- In 2015, the WTO reached a significant milestone with the receipt of its *500th trade dispute for settlement*.
- Expansion of the *Information Technology Agreement.*
- TRIPS Agreement amended to ease access to affordable medicine
- *Trade Facilitation Agreement (TFA)* enters into force.
- **Challenges** – Bias of favouring wealthier nations due to their greater negotiating power.

- Promoting policies that sometimes conflict with the economic interests and developmental needs of poorer countries.
- Issues such as agricultural subsidies remain highly contentious.

References

1. WTO| 30th anniversary of Marrakesh Agreement
2. WTO| Achievements of Marrakesh Agreement and WTO

