Brain-Inspired Image Sensor can Detect Miniscule Objects

Why in News?

A new study at **Indian Institue of science** (IISc) has shown that a brain-inspired image sensor can **go beyond the diffraction limit of light to detect miniscule objects** such as cellular components or nanoparticles invisible to current microscopes.

What is this Technology?

- The technique combines **optical microscopy with a neuromorphic camera and machine learning algorithms** and presents a major step forward in pinpointing **objects smaller than 50 nanometers in size.**
    - The **diffraction limit** prevents optical microscopes from distinguishing between two objects smaller than a certain size (typically 200-300 nanometers).
- The neuromorphic camera **mimics the way the human retina converts light into electrical impulses.**
    - In neuromorphic cameras, **each pixel operates independently, generating sparse and lower amount of data.** The process is similar to how the human retina works.
        - It allows the camera to “sample” the environment with much higher temporal resolution.
    - In **conventional cameras, each pixel captures the intensity of light falling on it** and these pixels are pooled together to reconstruct an image of the object.
- The experiment used the **neuromorphic camera to pinpoint individual fluorescent beads smaller than the limit of diffraction,** by shining laser pulses at both high and low intensities, and measuring the variation in the fluorescence levels.
    - **As the intensity increases**, the camera captures the **signal as an “ON”** event, while an **“OFF”** event is reported **when the light intensity decreases.**
    - The data from these events were **pooled together to reconstruct frames.**

What is the Significance of this Technique?

- This approach can have widespread applications in precisely tracking and understanding **stochastic processes** in biology, chemistry and physics.
    - It will help **understand the thumb rules of biological processes** like self-organisation.
    - The team was also able to closely track the movement of a fluorescent bead moving freely in an aqueous solution using this technique.

What is a Stochastic process?

- It is a process **involving the operation of chance** and is also known as **Random process.**
- For example, in radioactive decay every atom is subject to a fixed probability of breaking down in any given time interval.

What is Diffraction Limit?

- The diffraction limit is a fundamental physical limit on the ability of an optical system to resolve or

distinguish between two closely spaced objects.

- The **smallest resolvable distance between two-point sources of light is determined by the size of the aperture or lens** used to observe the objects, **as well as the wavelength of the light** being observed.
- In practical terms, this means that **even with a perfect lens or telescope, there is a limit to how much detail can be resolved in an image.**
- Objects that are closer together than the diffraction limit will appear blurred or indistinguishable in the image.

Source:TH