Advancing Robotics in Healthcare

For Prelims: DAKSHA, Vyom Mitra, MANAV, Artificial Intelligence and Robotics Technology Park (ARTPARK), National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS), Center for Advanced Manufacturing for Robotics and Autonomous Systems (CAMRAS), SSI Mantra, Drugs & Cosmetics Act, 1940, Totally Endoscopic Coronary Artery Bypass (TECAB), master-slave console model, Three Laws of Robotics**.**

For Mains: Application of Tele-Robotics in India, Measure and Regulation.

Source: TH

Why in News?

India achieved a significant milestone by performing **two complex heart surgeries** using the country's **first indigenous surgical tele-robotic system**, the **SSI Mantra**, over a physical distance of 286 km.

- These procedures represent a breakthrough in **robotic-assisted surgeries**, reducing geographical barriers to **advanced healthcare.**

What is SSI Mantra?

- **About:** SSI Mantra is **India's first indigenous surgical robotic system** to receive regulatory approval for telesurgery. It is developed by **SS Innovations.**
  - It was approved by the **Central Drugs Standard Control Organization (CDSCO),** the central regulatory authority under the **Drugs & Cosmetics Act, 1940.**
- **Key Features:**
  - **Ultra-low Latency:** Operates at a latency of **35–40 milliseconds,** enabling seamless remote operations without delay.
  - **High-precision Surgeries:** Designed for procedures like **Totally Endoscopic Coronary Artery Bypass (TECAB),** one of the most intricate cardiac surgeries.
  - **Regulatory Approval:** Recognized as the first robotic system certified for both telesurgery and remote surgical training (tele-proctoring).
- **Working Mechanism:** It operates on a **Master-Slave Console Model**, where:
  - The **Master surgeon** console remotely controls the surgery, allowing the lead surgeon to perform precise movements.
  - While the **Slave Console** near the patient executes commands with robotic instruments, enabling effective surgical care despite geographical distance.
- **Significance:** Facilitates **access to expert surgical care** in underserved or remote regions with limited medical facilities.
  - Overcomes **geographical barriers,** ensuring that world-class surgical expertise is available even in distant locations.
  - Minimally invasive techniques result in faster recovery times, fewer complications and reduced trauma and **Improved overall patient experiences**.

What are Robots?

- **Definition:** Robots are **automatic, self-controlled machines** capable of performing tasks with minimal human intervention.
    - It is a multidisciplinary field combining materials science, computer science, electronics, mechanics, and more.
- **Parts of Robots:** Includes **end-effectors** (similar to human hands), **manipulators** (analogous to arms), **locomotion devices, controllers, and sensors.**
- **Types of Robots:**
    - **Mobility-based:**
        - **Fixed/Static:** E.g., assembly robots.
        - **Mobile/Moving:** Wheeled or legged robots.
    - **Ability-based:**
        - **Type I:** Perform tasks better than humans (e.g., cutting).
        - **Type II:** Perform dangerous tasks to protect humans (e.g., space exploration).
    - **Shape-based:**
        - **Mechanical Robots:** Industrial robots.
        - **Animal Robots: Robo Dog:** AIBO, developed by Sony.
        - **Humanoid Robots:**
            - **Gynoid Robot:** Female-looking robots, such as Sofia.
            - **Android Robot:** Male-looking robots.
- **Laws of Robotics**: **Isaac Asimov's Three Laws of Robotics** create an ethical framework for robot-human interactions.
    - A robot **must not harm** a human or allow harm through inaction.
    - A robot **must obey human orders**, unless it conflicts with the First Law.
    - A robot **must protect its own existence**, as long as it doesn't conflict with the first two laws.
- **Note: Asimov's Zeroth Law** states that a **robot must prioritize humanity's well-being** above individual humans, prohibiting harm to humanity or allowing **harm through inaction**.
    - These **ethical, non-binding laws** discourage the use of **robots for military purposes** involving human harm.

What are the Various Applications of Robots?

- **Health Sector: Robotic Prosthetics where** advanced robotic limbs and exoskeletons enhance mobility and functionality for amputees, improving their quality of life.
    - **Robotic Surgery:** Minimally invasive procedures, faster recovery, and higher precision.
    - **Medical Service Robots:** Robots for tasks like sanitization, patient monitoring, and telemedicine.
        - Utilize UV-C light or hydrogen peroxide vapor to disinfect healthcare environments, ensuring clean and safe conditions.
- **Industries:** Robots are widely used in **electronics, automotive, and metal industries,** with China being the leader in installations.
    - In India, around **8,500 robots** were installed in 2023, a **59% increase** from the previous year.
- **Defense Sector:** Robots in warfare can either serve as autonomous killing machines **(e.g., Israel’s REX Mark II)** or assist soldiers in logistics, mine detection, and surveillance.
- **Agriculture:** Agricultural robots help in tasks like crop management, precision farming, and harvesting. In India, the development of robots **like Agribot is underway.**
- **Disaster Management:** Robots are used for search and rescue operations, such as navigating collapsed buildings **(e.g., Bandicoot robot for sewer cleaning).**
- **Space Sector:** Robotic systems are integral for space missions, such as the **Pragyan Rover on Chandrayaan-3 and NASA's Mars rovers.**

What is the Current Status of Robotics in India?

- **Current Status:** Between 2016 and 2021, the **operational stock of industrial robots in India doubled**. According to the **World Robotics Report 2024,** India ranked **7th** globally in terms of annual industrial robot installations.
    - However, India's robotics ecosystem has grown more slowly compared to some developed nations.
- **Made-in-India Robots:** India has developed several notable robots like
    - **DAKSHA (Defense)**: Automated mobile platform with stair-climbing and IED handling capabilities.
    - **Vyom Mitra (Space)**: ISRO's humanoid robot for Gaganyaan missions.
    - **MANAV (Technology)**: India's first 3D-printed humanoid robot with vision, sound processing, and interactive abilities.
- **Government Initiatives:**
    - **National Health Policy, 2017:** Recognizes the role of technology in improving healthcare services, emphasizing robotics and other advanced solutions.
    - **Draft National Strategy on Robotics (2023):** Aims to establish a **Robotics Innovation Unit (RIU)** to foster the development of robotics in healthcare and other sectors. The Indian government has established several research centres to foster robotics development:
    - The **Artificial Intelligence and Robotics Technology Park (ARTPARK)** and the **National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS)** focus on leveraging AI and robotics.
    - **Center for Advanced Manufacturing for Robotics and Autonomous Systems (CAMRAS)** aims to reduce India's reliance on imported robotics systems.
    - **The I-HUB Foundation for Cobotics (IHFC)** at IIT Delhi has launched various projects in healthcare, medical simulators, and drone applications.
    - **ISRO and Robotics:** India's space agency, ISRO, is developing humanoid robots for future manned missions. Vyom Mitra, a female robot astronaut, is set to be launched as part of India's Gaganyaan project in 2024.

What are the Challenges in Adopting Robotics in Healthcare?

- **High Initial Costs:** Robotic systems like **SSI Mantra** are expensive to acquire and maintain, posing financial challenges for many healthcare facilities, especially those with limited resources.
    - The **high upfront cost**, along with **ongoing maintenance and consumables**, makes adoption difficult for smaller or rural hospitals, widening healthcare disparities.
- **Training and Skill Gaps:** Operating robotic surgery systems requires specialized training for surgeons and medical staff. The **setup time for robotic systems** poses challenges in emergency cases like accidents.
    - The **steep learning curve and global shortage** of trained professionals delay adoption, particularly in developing countries.
- **Ethical Concerns:** Telesurgery raises **accountability and patient safety concerns,** as errors may **blur responsibility** between the surgeon, institution, or system provider, while technical issues like connectivity failures could compromise outcomes and trust.
- **Patient Trust:** Patients may hesitate to trust remote surgeries, fearing that the absence of a surgeon in the room compromises safety.
- **Job Loss**: Automation leads to job displacement, especially in manufacturing, with estimates suggesting that 300 million jobs could be lost due to automation.
- **Cybersecurity Risks**: Increased connectivity exposes robots to cyber-attacks, as seen in the 2017 **WannaCry** ransomware attack.

Way Forward

- **Costs-Effective Robotics:** Government support, subsidies and collaboration with private sectors and innovation in cost-effective robotics solutions can make these systems more affordable.
    - Hospitals can consider **leasing options or financing plans to distribute costs over time.**

- **Bridging Gaps:** Medical schools and training centers should **integrate robotic surgery training into their curricula** and online platforms and virtual training can be leveraged to provide global access to specialized education.
- **Managing Ethical Concerns:** Clear frameworks and regulations need to be established to **define accountability in telesurgery**, ensuring that all stakeholders (surgeon, hospital, system provider) **share responsibilities.**
    - Develop backup systems and fail-safes to **minimize the impact of technical failures** and ensure continuous patient safety during remote surgeries.
- **Mitigating Job Loss:** Upskilling and reskilling programs and promoting **human-robot collaboration models** where robots handle repetitive tasks while humans focus on decision-making and patient care.
- **Addressing Cybersecurity Risks:** Encryption, **multi-factor authentication, and regular software updates** and collaboration between healthcare institutions and cybersecurity experts will help **safeguard robots and medical data** from potential cyber threats.
    - Developing **standardized cybersecurity frameworks for robotic systems** in healthcare can help mitigate risks and increase system reliability.

Drishti Mains Question:

India has demonstrated significant advancements in developing cutting-edge robotics technologies but faces several challenges. What are the main reasons for this gap in the robotics sector, suggest measures.

UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims:

Q. Atal Innovation Mission is set up under the (2019)

(a) Department of Science and Technology

(b) Ministry of Labour and Employment

(c) NITI Aayog

(d) Ministry of Skill Development and Entrepreneurship

Ans: (c)

Mains

Q. COVID-19 pandemic has caused unprecedented devastation worldwide. However, technological advancements are being availed readily to win over the crisis. Give an account of how technology was sought to aid management of the pandemic. (2020)