Unit 5: Robotic Surgery in Biomedical Engineering

I. Pre-reading

A. New Vocabulary

Word / Term	Form	Definition / Synonym	Persian Translation
precision	n	accuracy and exactness of movement	دقت
manipulation	n	skillful handling or control	دستکاری / کنترل ماهرانه
minimally invasive	adj	requiring small incisions or entry points	کم‌تهاجمی
instrument	n	tool or device used in surgery	ابزار / وسیلهٔ جراحی
articulation	n	movement or flexibility of joints	مفصل‌بندی / حرکت مفصلی
incision	n	surgical cut made in the body	برش جراحی
anesthesia	n	loss of sensation during surgery	بیهوشی / بی‌حسی
autonomy	n	ability to operate independently	خودمختاری
haptic	adj	related to the sense of touch	لمسی
motion scaling	n	mapping large hand motions to smaller robot movements	مقیاس‌گذاریِ حرکت
teleoperation	n	controlling a robot from a distance	تله‌اپریشن / کنترل از راه دور
dexterity	n	skill in precise movements	چابکی / مهارت حرکتی
tremor reduction	n	filtering out small unwanted hand vibrations	کاهش لرزش / حذف لرزش
latency	n	delay between command and system response	تأخیر
cost-effectiveness	n	efficiency in relation to cost	مقرون‌به‌صرفه بودن

B. Pre-reading Questions

1. What is robotic surgery and how is it different from traditional open surgery?
2. How can robotic systems improve surgical precision and patient recovery?
3. In what ways do biomedical engineers contribute to surgical robot design and maintenance?
4. Why is haptic feedback important for surgeons using robotic systems?

II. Reading

Robotic Surgery in Biomedical Engineering

Robotic surgery is an advanced form of **minimally invasive surgery** in which surgeons use computer-controlled robotic systems to perform operations with high precision. Instead of working directly over the patient, the surgeon sits at a **console** and manipulates robotic arms equipped with surgical **instruments**. These instruments often have greater **dexterity** and **articulation** than the human hand, allowing for smoother and more controlled movements inside the body. Robotic surgery integrates engineering, medicine, and computer science to improve surgical performance and patient outcomes.

In a typical robotic platform, the surgeon's hand movements are captured at the console and translated into smaller, more precise actions by the robot. This process, known as **motion scaling**, enables delicate manipulation of tissues and structures that would be difficult to handle with traditional surgical tools. Through **teleoperation**, surgery can even be performed remotely, enabling expert surgeons to operate on patients in distant locations.

Biomedical engineers are essential in designing, calibrating, and maintaining surgical robots. They develop control algorithms, mechanical structures, and **feedback** systems to ensure smooth and accurate movement. A key feature is **haptic feedback**, which provides the sensation of touch or resistance, helping surgeons judge the force applied to tissues and improving procedural safety.

While global systems such as the **da Vinci** robot are widely recognized, a significant development in recent years has been the emergence of **Sina Robotic Surgery**, an advanced robotic surgical platform developed in Iran. The **Sina** system offers high-precision robotic arms, 3D **visualization**, tremor reduction, and finely articulated instruments designed for minimally invasive procedures. One of its notable strengths is its focus on adaptable engineering: biomedical engineers can modify and upgrade components locally, allowing continuous improvement and cost-effectiveness compared to imported systems. The Sina platform supports procedures in fields such as urology, gynecology, and general surgery, and serves as an important example of how regional innovation can expand access to high-quality robotic surgery.

Despite its advantages, robotic surgery—including systems like **Sina**—faces several challenges. These platforms are expensive to build and maintain, and surgeons need extensive training to operate them safely. Regular **sterilization**, hardware checks, and software updates are essential to ensure **accuracy** and patient safety. Ongoing research in biomedical engineering aims to reduce system costs, improve reliability, and incorporate **AI-assisted automation** to support surgeons in complex tasks.

In summary, robotic surgery demonstrates how the combination of mechanical precision, computer control, and biomedical expertise is transforming modern medicine. With the rise of innovative systems such as **Sina Robotic Surgery**, access to advanced, minimally invasive procedures continues to grow, and future platforms may achieve even higher levels of **autonomy** and efficiency.

III. Post-reading

A. True (T), False (F), or Not Given (NG)

1. Robotic surgery allows surgeons to perform operations using computer-controlled robotic arms.
2. In modern robotic surgery, the surgeon stands directly beside the patient while controlling the robotic instruments.
3. Motion scaling helps convert the surgeon's large hand movements into smaller, more precise robotic actions.

4. The Sina robotic surgery system was developed outside of Iran.
5. The Sina system includes features such as 3D visualization and tremor reduction.
6. The reading states that the Sina system is only used for urological procedures.
7. Biomedical engineers contribute to designing, calibrating, and maintaining robotic surgical systems.

B. Multiple Choice

1. What is one major advantage of robotic surgery mentioned in the text?
   a) Larger incisions b) Faster recovery and less tissue damage
   c) No need for engineers d) Completely automatic procedures
2. Which component does the surgeon use to control the robotic arms?
   a) Sterilizer b) Console
   c) Camera port d) Anesthesia machine
3. What does **motion scaling** do in robotic surgery?
   a) Speeds up the robot's movements b) Converts large hand motions into smaller robotic actions
   c) Enlarges the surgeon's view d) Cleans surgical instruments automatically
4. What is one notable feature of the **Sina Robotic Surgery** system?
   a) It provides no 3D visualization c) It includes tremor reduction and articulated instruments
   b) It cannot be upgraded d) It requires open surgical incisions
5. Which of the following is mentioned as a challenge in robotic surgery?
   a) Lack of visualization b) High system cost and need for extensive training
   c) No involvement of engineers d) Complete autonomy of surgical robots

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C. Fill in the blanks

1. The surgeon operates the robotic system from a _____ equipped with visual and control interfaces.
2. Robotic surgery usually requires only small _____ in the patient's body.
3. _____ surgery uses computer-controlled robotic arms for precise operations.
4. _____ scaling translates large human hand movements into fine robotic actions.
5. Biomedical engineers help develop _____ feedback so surgeons can sense tissue resistance.
6. The Sina system provides 3D _____ and tremor reduction to enhance surgical precision.
7. Biomedical _____ design, calibrate, and maintain the hardware and software of robotic platforms.
8. A major difficulty in robotic surgery is the need for proper training and high _____ to ensure safety.
