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Anjugramam - Kanyakumari Main Road, Palkulam, Variyoor P.O. - 629 401, Kanyakumari District.

Department of Biomedical Engineering

VI Semester

CBM 370 - Wearable Devices

Unit- 5 APPLICATIONS OF WEARABLE SYSTEMS

5.1 Medical Diagnostics

- Wearable technologies can be innovative solutions for healthcare problems.
- Some wearable technology applications are designed for prevention of diseases and maintenance of health, such as weight control and physical activity monitoring.
- Wearable devices are also used for patient management and disease management. The wearable applications can directly impact clinical decision making.
- Wearable technologies enable the continuous monitoring of human physical activities and behaviors, as well as physiological and biochemical parameters during daily life.
- The most commonly measured data include vital signs such as heart rate, blood pressure, and body temperature, as well as blood oxygen saturation, posture, and physical activities through the use of electrocardiogram (ECG), ballistocardiogram (BCG) and other devices.
- Continuous and real-time monitoring is essential for better management of patients with chronic illnesses, including, cardiovascular diseases, diabetes, and neurological disorders. According to the World Health Organization (WHO), chronic diseases account for three quarters (75%) of all deaths around the world and impose high economic burdens.

Wearable devices have revolutionized medical diagnostics by enabling continuous monitoring, early detection, and real-time health insights. Some key applications include:

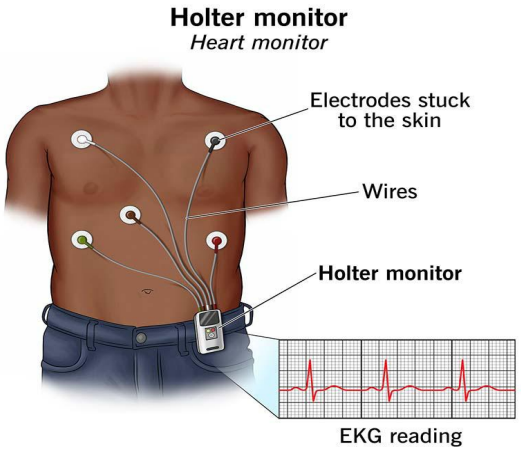
1. Cardiovascular Monitoring:

- **ECG Smartwatches:** ECG (Electrocardiogram) smartwatches have become increasingly popular for heart health monitoring. While they are not a replacement for medical-grade ECG machines, they can provide valuable insights into heart rhythm and detect conditions like atrial fibrillation (AFib).
  Example: 1. Apple Watch Series (Series 4 and later)
  2. Samsung Galaxy Watch Series

- **Wearable Blood Pressure Monitors:** Wearable blood pressure (BP) monitors work by measuring the force of blood against artery walls, either using an **inflatable cuff** (similar to traditional BP monitors) or **optical sensors** (which estimate BP based on blood flow changes). Frequent readings outside the clinic can help confirm a diagnosis of hypertension. Wearable blood pressure monitors facilitate remote monitoring, allowing healthcare providers to track patients' blood pressure trends.

  Example: 1. Omron Heart Guide

- **Chest Straps & Patches:** Chest straps and patches provide more accurate heart and health monitoring than wrist-based wearables. They are widely used for ECG, heart rate, respiratory rate, and continuous monitoring **in both** medical and fitness settings.

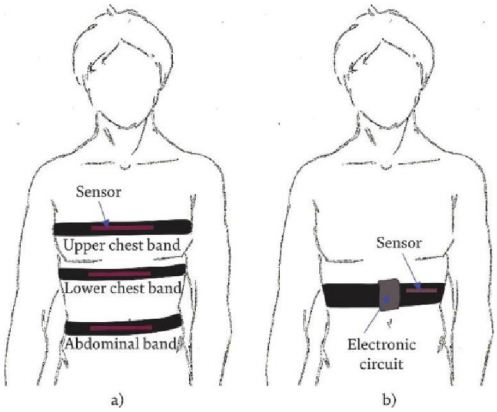


2. Blood Glucose Monitoring:

Wearable glucose monitors help people with diabetes and those tracking metabolic health by continuously measuring glucose levels. These devices use Continuous Glucose Monitoring (CGM) **or** non-invasive sensor technology**.** CGMs involve a small sensor inserted just under the skin (usually on the abdomen or back of the arm) that measures glucose levels in the interstitial fluid. This sensor is connected to a transmitter that wirelessly sends glucose data to a receiver (a dedicated device, a smartphone app, or an integrated insulin pump). Readings are taken every few minutes, providing a dynamic picture of glucose levels throughout the day and night.

3. Respiratory Monitoring:

- Wearable respiratory monitors help track breathing rate, lung function, and oxygen levels, making them useful for asthma, COPD, sleep apnea**,** and fitness tracking**.** These devices use chest sensors, wrist-based sensors, or smart patches to monitor respiration rate (RR), oxygen saturation (SpO_2), and airflow**.**

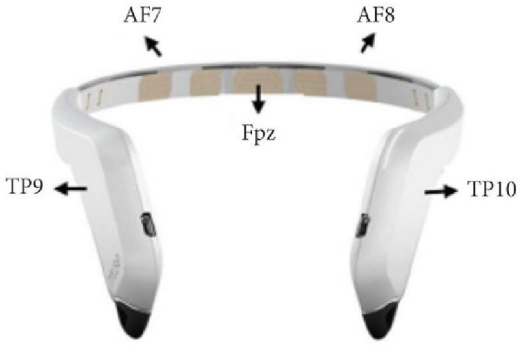


These can be broadly categorized by their sensing mechanism and placement:

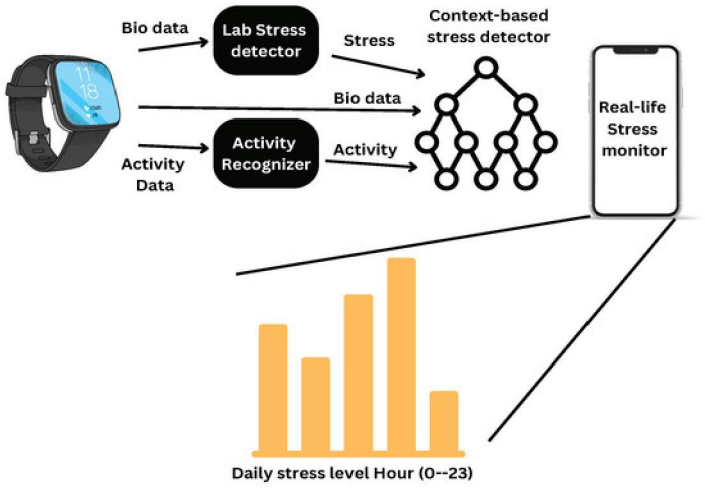
- ✓ Respiratory Inductance Plethysmography (RIP)
- ✓ Resistance-Based Sensors
- ✓ Capacitance-Based Sensors:
- ✓ Piezoresistive Sensors
- ✓ Inertial Measurement Units (IMUs)

4. Neurological & Mental Health Monitoring:

- **EEG Headbands** track brain activity to aid in epilepsy detection and mental health assessments.
- Wearables assess stress, anxiety, and depression using physiological markers like heart rate variability (HRV).
- Smartwatches can help detect early signs of **Parkinson's disease** via motion tracking.



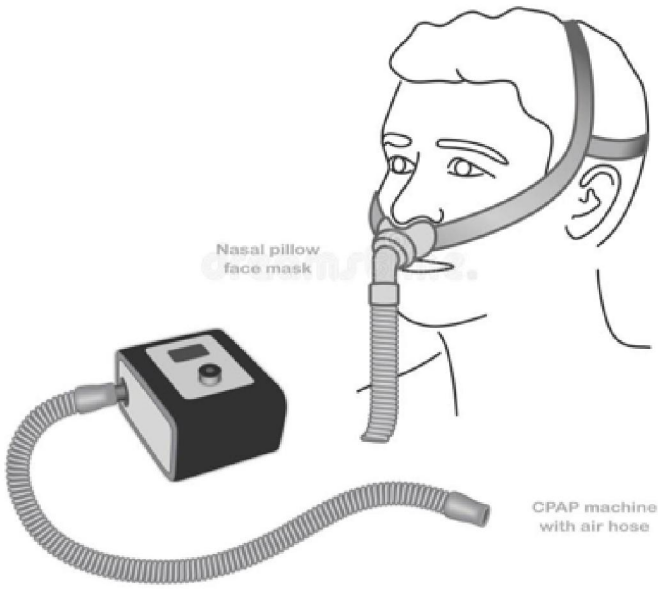
EEG Headband



Stress level detector

5. Sleep Disorder Diagnosis:

- ✓ Wearable devices for sleep disorder diagnosis help track sleep patterns, breathing, oxygen levels, and movement to detect issues like sleep apnea, insomnia, and restless leg syndrome.
- ✓ Devices like **Oura Ring** track sleep cycles and oxygen saturation.



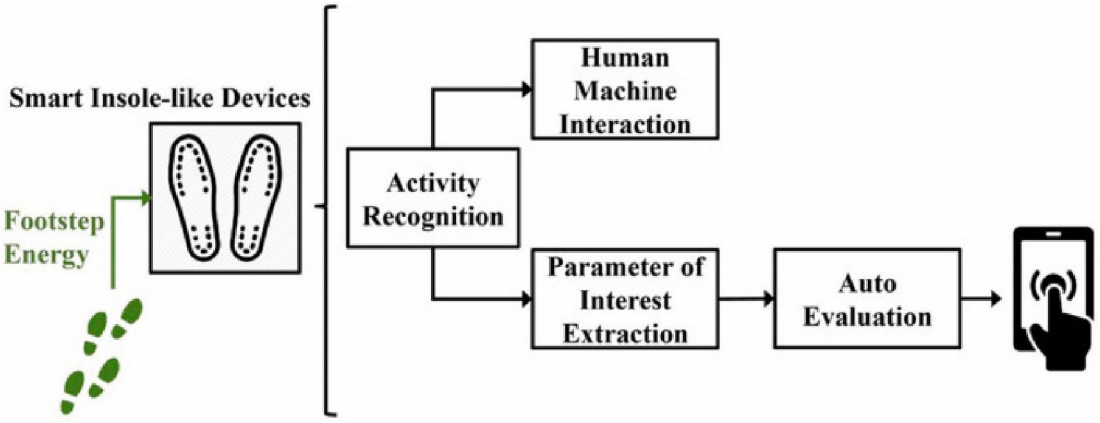
[https://www.dreamstime.com/illustration/medical-sleep-device.html]

6. Temperature & Infection Monitoring:

- Wearable thermometers can detect fever, potentially identifying infections early (e.g., in sepsis monitoring).
- Smartwatches with temperature sensors can help track ovulation cycles and early signs of illness.

7. Physical Rehabilitation & Injury Recovery:

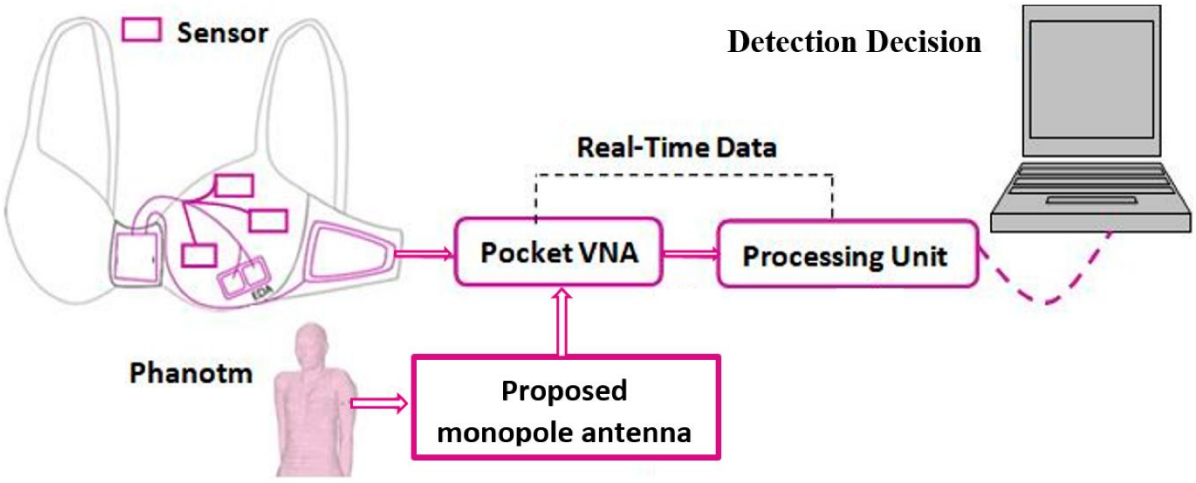
- **Smart Insoles & Exoskeletons** assist in gait analysis and post-stroke recovery.
- Motion sensors in wearables help assess recovery progress in orthopedic and sports injuries.



[https://www.sciencedirect.com/science/article/abs/pii/S2352648322000368]

8. Cancer Detection & Management:

- Wearable biosensors detect early biomarkers of diseases, including cancer.
- Some wearables track UV exposure to help prevent skin cancer.



https://www.mdpi.com/2079-6374/13/1/87

❒ The proposed sensors use microwave signal for breast screening. The antenna-based sensor is composed of a monopole antenna with an overall compact size of 24 × 45 mm^2. The proposed sensors have been placed on fabricated phantoms and measured using a vector network analyzer (VNA).

9. Personalized Medicine & AI Integration:

- AI-powered wearables analyze user data to provide personalized healthcare insights.
- Continuous monitoring helps in predictive analytics, reducing hospitalizations.
- **Continuous Monitoring:** AI processes real-time sensor data (e.g., ECG, temperature, impedance, RF signals).
- **Early Disease Detection:** Machine learning models detect anomalies and predict diseases like breast cancer, arrhythmias, or neurological disorders.
- **Personalized Insights:** AI tailors recommendations based on an individual's health patterns, genetics, and medical history.
- **Automated Alerts:** Wearables notify users and doctors about critical health events (e.g., tumor growth, heart issues).

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