UNIT I INTRODUCTION TO WEARABLE SYSTEMS AND SENSORS

Wearable Systems- Introduction, Need for Wearable Systems, Drawbacks of Conventional Systems for Wearable Monitoring, Applications of Wearable Systems, Types of Wearable Systems, Components of wearable Systems. Sensors for wearable systems-Inertia movement sensors, Respiration activity sensor, Inductive plethysmography, Impedance plethysmography, pneumography, Wearable ground reaction force sensor.

Chapter 1

Wearable Systems- Introduction

Wearable technology is any kind of electronic device designed to be worn on the user's body. Such devices can take many different forms, including jewelry, accessories, medical devices, and clothing or elements of clothing. The term wearable computing implies processing or communications capabilities, but in reality, the sophistication among wearables can vary.

The most sophisticated examples of wearable technology include artificial intelligence (AI) hearing aids, Google Glass and Microsoft's HoloLens, and a holographic computer in the form of a virtual reality (VR) headset. An example of a less complex form of wearable technology is a disposable skin patch with sensors that transmit patient data wirelessly to a control device in a healthcare facility.

Need for wearables

Fundamentally, wearables can perform the following basic functions or unit operations

• Sense

• Process (Analyze)

• Store

• Transmit

• Apply (Utilize)

Of course, the specifics of each function will depend on the application domain and the

wearer, and all the processing may occur actually on the individual or at a remote location

(e.g., command and control center for first responders, fans watching the race, or viewers

enjoying the mountaineer’s view from the Mount Everest base camp).

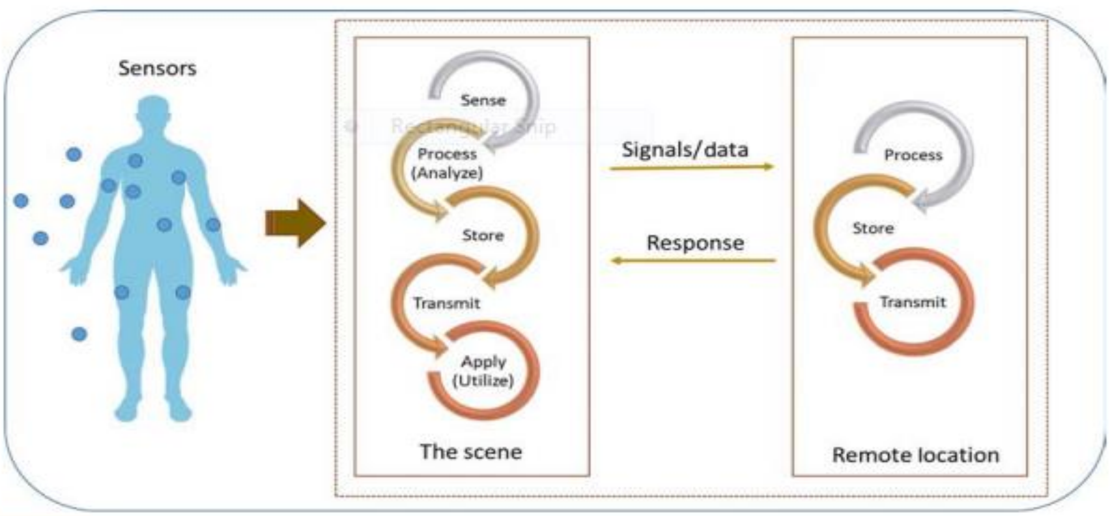

FIGURE 2 Unit operations in obtaining situational awareness: the role of wearables.

Figure 2 is a schematic representation of the unit operations associated with obtaining and

processing situational data using wearables. For example, if dangerous gases are detected by a wearable on a first responder, the data can be processed in the wearable and an alert issued. Simultaneously, it may be transmitted to a remote location for confirmatory testing and the results – along with any appropriate response (i.e., put on a gas mask) – can be communicated to the user in real-time to potentially save a life . This same philosophy can also be used by an avid gamer who might change his strategy depending on what "weapons" are available to him and how his opponents are performing. Each of these scenarios requires personalized mobile information processing, which can transform the sensory data into information and then to knowledge that will be of value to the individual responding to the situation. While wearables are being used in many fields, as discussed, this chapter will focus primarily on wearables in the healthcare domain. Wearables provide an unobtrusive way to longitudinally monitor an individual – not just during the day but, over the individual's life-time. Such an expansive view of the individual will be valuable in detecting changes over time and help in early detection of problems and diseases leading to preemptive care and hence, a better quality of life. Inferring the potential of wearables in other application domains should be straightforward and can be accomplished by instantiating the fundamental principles and concepts presented here.

Attributes of wearables

A sensor is defined as "a device used to detect, locate, or quantify energy or matter, giving a signal for the detection of a physical or chemical property to which the device responds". Not all sensors are necessarily wearable, but all wearables, as discussed earlier and shown in Figure 2, must have sensing capabilities. The key attributes required of an ideal wearable are shown in Figure 4. From a physical standpoint, the wearable must be lightweight and the form factor should be variable to suit the wearer. For instance, if the form factor of the wearable to monitor the vital signs of an infant prone to sudden infant death syndrome prevents the infant from (physically) lying down properly, it could have significant negative implications. The same would apply to an avid gamer – if the form factor interferes with her ability to play "naturally," the less likely that she would be to adopt or use the technology. Esthetics also plays a key role in the acceptance and use of any device or technology. This is especially important when the device is also seen by others i.e., the essence of fashion. Therefore, if the wearable on a user is likely to be visible to others, it should be esthetically pleasing and, optionally, even make a fashion statement while meeting its functionality. In fact, with wearables increasingly becoming an integral part of everyday lives, the sociological facets of the acceptance of wearables open up exciting avenues for research. Ideally, a wearable should become such an integral part of the wearer's clothing or accessories that it becomes a "natural" extension of the individual and "disappears" for all intents and purposes. It must have the flexibility to be shape-conformable to suit the desired end-use; in short, it should behave like the human skin. The wearable must also have the multifunctional capability and be easily configurable for the desired end-use application. Wearables with single functionality (e.g., measuring just the heart rate) are useful, but in practical applications, more than one parameter is typically monitored; and, having multiple wearables – one for each function or data stream – would make the individual look like a cyborg and deter their use even if the multiple data streams could be effectively managed. The wearable's responsiveness is critical, especially when used for real-time data acquisition and control (e.g., monitoring a first responder in a smoke-filled scene). Therefore, it must be "always on." Finally, it must have sufficient data bandwidth to enable the degree of interactivity, which is key to its successful use. Finally, wearables can be classified based on their field of application, which can range from health and wellness monitoring to position tracking. "Information processing" is listed as one of the application areas because many of these traditional functions such as processing e-mail can now be done on a wearable in the form of a wristwatch. It is important to note that not all the classes are mutually exclusive. For instance, a wearable can be multifunctional, active, noninvasive, and be reusable for health monitoring. The proposed taxonomy serves two key functions: First, it helps in classifying the currently available wearables so that the appropriate ones can be selected depending upon the operating constraints; second, it helps in identifying opportunities for the design and development of newer wearables with performance attributes for sp ecific areas that need to be addressed.

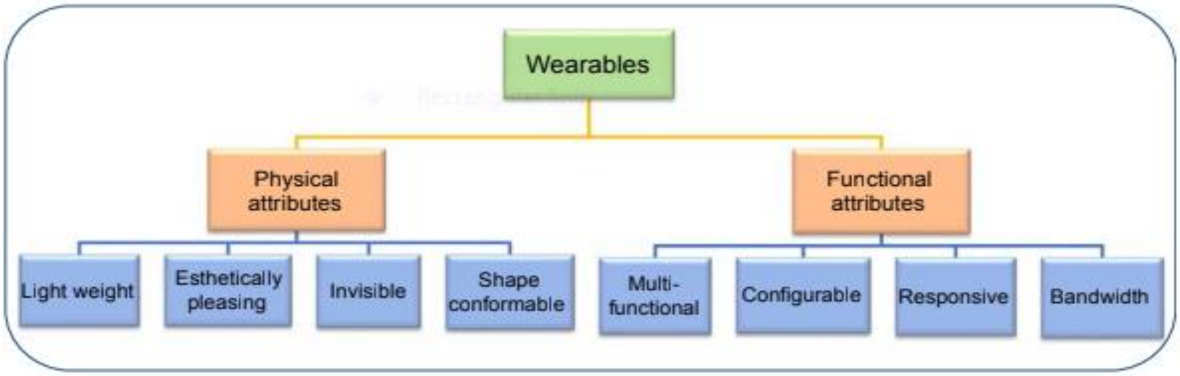

FIGURE 4 Key attributes of wearables.

Taxonomy for wearables

Figure 5 shows the proposed taxonomy for wearables. To begin with, they can be classified as a single function or multifunctional. They can also be classified as invasive or noninvasive. Invasive wearables (sensors) can be further classified as minimally invasive, those that penetrate the skin (subcutaneous) to obtain the signals, or as an implantable, such as a pacemaker. Implantable sensors require a hospital procedure to be put into place inside the body. Noninvasive wearables may or may not be in physical contact with the body; the ones not in contact could either be monitoring the individual or the ambient environment (e.g., a camera for capturing the scene around the wearer or a gas sensor for detecting harmful gases in the area). Noninvasive sensors are typically used in systems for continuous monitoring because their use does not require extensive intervention from a healthcare professional.

Wearables can also be classified as active or passive depending upon whether or not they need the power to operate; pulse oximetry sensors fall into the former, while a temperature probe is an example of a passive wearable that does not require its power to operate. Yet another view of wearables is the mode in which the signals are transmitted for processing wired or wireless. In the former, the signals are transmitted over a physical data bus to a processor; in the wireless class of wearables, the communications capability is built into it, which transmits the signals wirelessly to a monitoring unit.

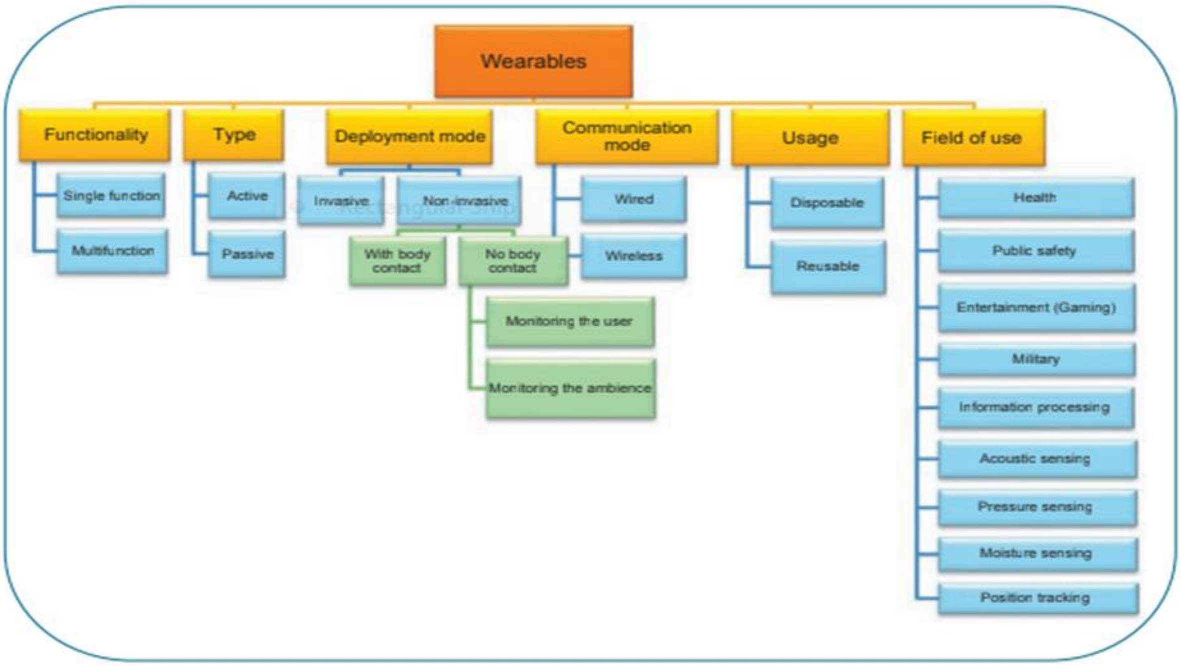

FIGURE 5 The taxonomy for wearables.