

1.2.1 Enrollment and recognition phases

How does a biometric system identify a user based on his physical and/or behavioral traits? This process consists of two main phases, namely, enrollment and recognition (see [Figure 1.3](#)). During the *enrollment* phase, the biometric data is acquired from the individual and stored in a database along with the person's identity. Typically, the acquired biometric data is processed to extract salient and distinctive features. In many cases, only the extracted feature set gets stored, while the raw biometric data is discarded. During the *recognition* phase, the biometric data is re-acquired from the individual and compared against the stored data to determine the user identity. Thus, a biometric system is essentially a pattern recognition (or a pattern matching) system consisting of four basic building blocks, namely, (a) sensor, (b) feature extractor, (c) database, and (d) matcher as shown in [Figure 1.3](#). These four modules will now be discussed in turn.

1.2.2 Sensor module

A suitable user interface incorporating the biometric sensor or reader is needed to measure or record the raw biometric data of the user. For example, an optical fingerprint sensor may be used to image the friction ridge pattern at the tip of the finger. The design of a good user (or human-machine) interface is critical for the successful implementation of a biometric system. An intuitive, ergonomic, and easy to use interface may facilitate rapid user habituation and enable the acquisition of good quality biometric samples from the user.

The quality of the raw biometric samples also depends on the characteristics of the sensor used. For most biometric modalities, the raw biometric data is in the form of two-dimensional images (e.g., fingerprint, face, iris, etc.). Exceptions include voice (1-dimensional amplitude signals), online signature (pen pressure, position, and velocity), odor and DNA (chemical-based). For image-based data, factors like resolution, frame rate, and sensitivity of the camera play an important role in determining the image quality. [Figure 1.4](#) shows fingerprint images at two different