By far, all the major hyperspectral imaging algorithms described in this book have been redesigned for implementation as real-time processing algorithms in Part II. Specifically, Part II studied the band-interleaved-pixel/sample/line (BIP/BIS/BIL) data acquisition format for hyperspectral target detection that uses a causal sample correlation/covariance matrix (CSCRM/CSCVM) to perform real-time detection. At this point we have not taken up the issue of designing and developing algorithms according to the other data acquisition format, the band-sequential (BSQ) format, which collects data band image by band image, shown in Fig. 1.2 and reproduced in Fig. 4.1, where \((x, y)\) indicates the spatial coordinate of a data sample vector or pixel vector and \(\lambda\) is a parameter used to specify spectral bands.
To understand the difference between the BIS/BIP/BIL and BSQ formats, we consider the difference between two image processes, sequential and progressive. In general, sequential image processing processes an 8-bit image using 8-bit grayscales to fully process each of its pixels sequentially pixel by pixel without having to revisit the pixels. An example is downloading images directly from a Web site. By contrast, progressive image processing using 8-bit grayscales processes each pixel of an 8-bit image bit by bit. As a result, each image pixel is revisited over and over again and is processed eight times. An example is the bit plane coding for image enhancement and compression, where Fig. 4.2 shows an 8-bit grayscale image encoded in Fig. 4.2a and decoded in Fig. 4.2b by bit plane coding [see Chap. 3 in Gonzalez and Woods (2007)].

Thus, according to the preceding descriptions, a sequential image process is actually a BIS/BIP/BIL process, whereas a progressive image process is a BSQ process. Therefore, analogous to 8-bit plane coding, which can encode and decode an 8-bit grayscale image progressively by increasing the grayscale resolution bit by bit gradually, we can also design progressive hyperspectral band processing (PHBP) that processes data progressively by increasing band resolution gradually band by band according to the BSQ format. Part IV is devoted to extending real-time constrained energy minimization (Chap. 5) and real-time anomaly detection (Chap. 6) in Part II to their progressive and recursive band processing counterparts.


Fig. 4.2 8-bit grayscale image encoded and decoded by bit plane image coding. (a) Progressive 8-bit grayscale processing of bit plane coding from least significant bit (bit plane 1) to most significant bit (bit plane 8) (Gonzales and Woods 2008). (b) Progressive 8-bit grayscale reconstruction processing from the two, three, and four most significant bit planes (bit planes 8, 7, 6, 5) to 8-bit image (Gonzales and Woods 2007)