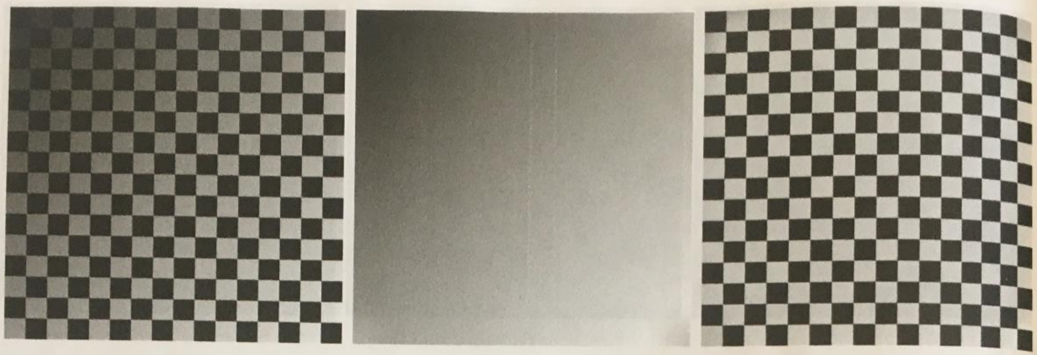
EXAMPLE 3.18: Shading correction using lowpass filtering.

One of the principal causes of image shading is nonuniform illumination. *Shading correction* (also called *flat-field correction*) is important because shading is a common cause of erroneous measurements, degraded performance of automated image analysis algorithms, and difficulty of image interpretation by humans. We introduced shading correction in Example 2.7, where we corrected a shaded image by dividing it by the shading pattern. In that example, the shading pattern was given. Often, that is not the



a b c

FIGURE 3.48 (a) Image shaded by a shading pattern oriented in the −45° direction. (b) Estimate of the shading patterns obtained using lowpass filtering. (c) Result of dividing (a) by (b). (See Section 9.8 for a morphological approach to shading correction).

case in practice, and we are faced with having to estimate the pattern directly from available samples of shaded images. Lowpass filtering is a rugged, simple method for estimating shading patterns.

Consider the 2048×2048 checkerboard image in Fig. 3.48(a), whose inner squares are of size 128×128 pixels. Figure 3.48(b) is the result of lowpass filtering the image with a 512×512 Gaussian kernel (four times the size of the squares), $K = 1$, and $\sigma = 128$ (equal to the size of the squares). This kernel is just large enough to blur-out the squares (a kernel three times the size of the squares is too small to blur them out sufficiently). This result is a good approximation to the shading pattern visible in Fig. 3.48(a). Finally, Fig. 3.48(c) is the result of dividing (a) by (b). Although the result is not perfectly flat, it definitely is an improvement over the shaded image.