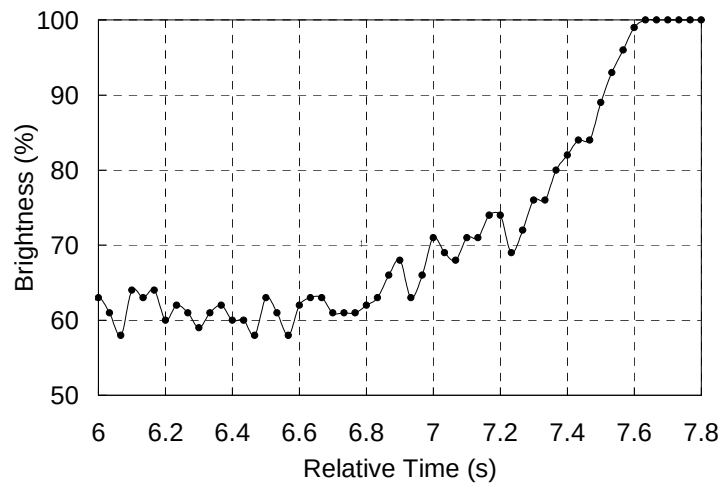


recording over time. A single pixel close to the center of the north face roofline was selected and the color of the pixel, expressed as values of hue, saturation, and brightness, was recorded for each frame between 6.0 s and 7.8 s, where  $t = 0$  s corresponds to the start of descent of the east penthouse (see Table 5-3). The brightness was found to provide the best indicator of change since the brightness of a pixel representing the sky above the building had a value of 100 percent while a pixel representing the roofline of the building (granite façade) had a brightness of roughly 60 percent for the pixel selected. The brightness of the selected pixel, expressed as a percent, is plotted versus time in Figure 12–75. From 6.0 s to 6.9 s, the brightness is seen to oscillate around a value of 60 percent indicating no vertical movement. Beginning at roughly 6.9 s the brightness increases irreversibly to a value of 100 percent at which time the pixel under study represents the sky. Thus, the relative time at which the roofline began to move was estimated as 6.9 s. The time when the roofline dropped from view behind the buildings in the foreground was 12.3 s. Thus, the time the roofline took to fall 18 stories was approximately 5.4 s.

The theoretical time for free fall (i.e., at gravitational acceleration) was computed from,

$$t = \sqrt{\frac{2h}{g}} \quad (1)$$

where  $t$  = time (s),  $h$  = distance (ft), and  $g$  = gravitational acceleration ( $32.2 \text{ ft/s}^2$ ). Upon substitution of  $h = 242 \text{ ft}$  in the above equation, the estimated free fall time for the roofline to descend 18 stories was approximately 3.9 s. Thus, the average time for the upper 18 stories to collapse, based on video evidence, was approximately 40 percent longer than the computed free fall time.



**Figure 12–75 Brightness of a pixel on the north face roofline as WTC 7 began to collapse.**

To obtain a better understanding of the vertical motion of the building in the first several seconds of descent, the motion of the north face was studied in more detail by tracking the vertical position of a point near the center of the roofline using the same video. In the following discussion, the time at which motion of the roofline was first perceived (6.9 s) is taken as time zero.

Figure 12–76 presents a plot of the downward displacement data shown as solid circles. A curve fit is also plotted with these data as a solid line. A function of the form  $z(t) = A\{1 - \exp[-(t/\lambda)^k]\}$  was selected