Algorithm test_range_measurement($z_t^k, \bar{\mathcal{X}}_t, m$):
  $p = q = 0$
  for $m = 1$ *to* M *do*
    $p = p + z_{\text{short}} \cdot p_{\text{short}}(z_t^k \mid x_t^{[m]}, m)$
    $q = q + z_{\text{hit}} \cdot p_{\text{hit}}(z_t^k \mid x_t^{[m]}, m) + z_{\text{short}} \cdot p_{\text{short}}(z_t^k \mid x_t^{[m]}, m)$
      $+ z_{\text{max}} \cdot p_{\text{max}}(z_t^k \mid x_t^{[m]}, m) + z_{\text{rand}} \cdot p_{\text{rand}}(z_t^k \mid x_t^{[m]}, m)$
  endfor
  if $p/q \leq \chi$ *then*
    return accept
  else
    return reject
  endif

Table 8.5 Algorithm for testing range measurements in dynamic environment.

measurement is then rejected if its probability of being caused by an unexpected obstacle exceeds a user-selected threshold χ.

Table 8.5 depicts an implementation of this technique in the context of particle filters. It requires as input a particle set $\bar{\mathcal{X}}_t$ representative of the belief $\overline{bel}(x_t)$, along with a range measurement z_t^k and a map. It returns "reject" if with probability larger than χ the measurement corresponds to an unexpected object; otherwise it returns "accept." This routine precedes the measurement integration step in MCL.

Figure 8.22 illustrates the effect of the filter. Shown in both panels are a range scan, for a different alignment of the robot pose. The lightly shaded scans are above threshold and rejected. A key property of our rejection mechanism is that it tends to filter out measurements that are "surprisingly" short, but leaves others in place that are "surprisingly" long. This asymmetry reflects the fact that people's presence tends to cause shorter-than-expected measurements. By accepting surprisingly long measurements, the approach maintains its ability to recover from global localization failures.

Figure 8.23 depicts an episode during which a robot navigates through an environment that is densely populated with people (see Figure 8.21). Shown there is the robot's estimated path along with the endpoints of all scans incorporated into the localizer. This figure shows the effectiveness of removing measurements that do not correspond to physical objects in the map: