Guiding Visually Impaired Persons in Unfamiliar Environments

Visually impaired people frequently have a harder time familiarizing themselves with new environments. The absence of sight prevents the exploration of new and unknown places to happen at a quick pace, while remembering already traveled routes requires sufficient information about the route to be communicated to the visually impaired person. Limiting ourselves to the area inside buildings, if a device is used to replace eye-sight up to a point in this situation, what should such a device do? The following sections seek to sketch a possible answer.

Required Functionality

The device should:

1. Remember a specific location up to a specific area granularity, such as a specific room or corridor, and be able to recognize that the user is currently in such a remembered location.
2. Remember a route from point A to point B and be able to help a user walk between these points by steering the user in the right direction.
3. Be able to store labels, extra instructions to the user or descriptions for remembered locations, routes or route segments and be able to present them to the user either upon request or upon reaching the specific location, route or enter or leave the specific route segment for which the above item has been stored.

Implementation

Sensors

The device could implement the below sensors:

1. Wireless Networking 802.11: For location identification using the strength of nearby wireless signals.
2. Sonar: For identifying nearby objects and building infrastructure.
3. Camera: For recognizing objects.
4. Light Detector: For finding possible openings in building infrastructure, e.g. doors.
5. Sound Detector: For recognizing specific “danger” sounds, e.g. the sound of moving cars.
6. Accelerometer: For location identification by measuring human walking steps. Also, for giving specific instructions to the device, e.g. flip it to make it switch on.

Localization

The wireless 802.11 functionality should be used to sniff nearby wireless networks, which are nowadays widely deployed in hotels, apartment houses and other large buildings. These measurements of the strength of wireless signals should provide a sufficient “fingerprint” of the current location, i.e. given a specific measurement of signal strengths at a point and a list of previously identified locations together with the signal strengths of corresponding neighboring wireless networks, it should be able to find the location corresponding to the given signal strengths if it is on the list, within a sufficiently small margin of error.

To fulfill this goal, the following were tried using training data gathered from the NYU Library:

1. Neural Network: A network with 2 hidden layers, trained using back-propagation. Seems to be correct within 20 to 25 feet.
2. Weighted Nearest Neighbor Approach: Takes a number of known signal strengths which are close in Euclidian distance to the given point and finds a weighted average of their location. Seems to be correct within 35 feet.
3. Combined Neural and Weighted Nearest Neighbor Approach: Uses a Neural Network predictor to create many (e.g. 10 by 10) artificial extra nearest neighbors to a given point and then uses the Weighted Nearest Neighbor approach on them. Does not seem to improve accuracy beyond the neural network approach.
4. Expectation Maximization algorithm: Seems to be totally off.
5. A Mixture of Gaussians, One per Angle of Signal: The idea is that the signal strength follows a Gaussian distribution at each angle of direction from the wireless access-point and that the variance of all the Gaussian distributions also follows a Gaussian distribution. Cannot be computed using the current limited data-set.

   Although (1), the neural network approach sounds the most promising, it is only still a very simple neural network which has been used (a gradient descent network with 2 hidden layers, 13 hidden neurons and trained using back-propagation) and more work is necessary. Other parameters of the network were tweaked, such as varying the learning-rate and the number of hidden neurons. These were found to perform best at values of 0.01 and 13 respectively. Also, 20 to 25 feet accuracy are not sufficient for steering a person on a route path but might be ok for identifying a given room.

   A port of our Neural Network has been completed which works on a mobile phone and software has been written which can take 802.11 wireless measurements on the phone by using its built-in WLAN card. The software can also make use of the phone's accelerometer for taking commands from the user. Further testing of the software and its accuracy is now required.