Exocentric Sensing – Proxemics

In behavioral psychology, influences of interpersonal distances on social interactions between people have been studied for over four decades. The term *proxemics*, coined by Edward T. Hall, describes influence of interpersonal distances in animal and man **[6]**. The following list describes the American proxemic distances; note that such distances vary with culture and environment.

* Intimate Distance (Close Phase): 0-6 inches
* Intimate Distance (Far Phase): 6-18 inches
* Personal Distance (Close Phase): 1.5-2.5 feet
* Personal Distance (Far Phase): 2.5-4 feet
* Social Distance (Close Phase): 4-7 feet
* Social Distance (Far Phase): 7-12 feet
* Public Distance (Close Phase): 12-25 feet
* Public Distance (Far Phase): 25 feet or more

Proxemics plays a very important role in interpersonal communication, but people who are blind and visually impaired do not have access to this information. In **[9]**, Ram and Sharf introduced The People Sensor: an electronic travel aid, for individuals who are blind, designed to help detect and localize people and objects in front of the user. The distance between the user and an obstacle is found using ultrasonic sensors and communicated through the rate of short vibratory pulses, where the rate is inversely proportional to distance. However, the researchers did no user testing to determine the usefulness of their technology. Tactile rhythms delivered using a vibrotactile belt were used in [4] to convey distance information during waypoint navigation. Time between vibratory pulses was varied using one of two schemes: monotonic (rate is inversely proportional to distance) or three-phase-model (three distinct rhythms mapped to three distances).

Distinct tactile rhythms are promising for use with multidimensional tactons [1, 2], which are vibratory signals used to communicate abstract messages [2] by changing the dimensions of the signal including frequency, amplitude, location, rhythm, etc. Based on pilot test results, we chose to pursue distinct rhythms over monotonic rhythms as users find it difficult to identify interpersonal distances using monotonic rhythms as the vibratory signal varies smoothly with changes in distance.

Existing computer vision techniques for face detection [7] can provide a wealth of non-verbal cues for social interaction, including the number of people in the user’s visual field, where people are located relative to the user, coarse information related to gaze direction (pose estimation algorithms could be used to extract finer estimates of pose), and the approximate distance of the person from the user based on the size of the face image.

As shown in Figure 3, the output of the face detection process (indicated by a green rectangle on the image) provided by the Social Interaction Assistant is directly coupled with the haptic belt. Every frame in the video sequence captured by the Social Interaction Assistant is divided into 7 regions. After face detection, the region to which the top-left corner of the face detection output belongs is identified (as shown by the star in Figure 3). This region directly corresponds to the tactor on the belt that needs to be activated to indicate the direction of the person with respect to the user. To this end, a control byte is used to communicate between the software and the hardware components of the system. Regions 1 through 7 are coded into 7 bits on the parallel port of a PC. Depending on the location of the face image, the corresponding bit is set to 1. The software also controls the duration of the vibration by using timers. The duration of a vibration indicates the distance between the user and the person in his or her visual field. The longer the vibration, the closer the people are, which is estimated by the face image size determined during the face detection process.

An overall perspective of the system and its process flow is given below. When a user encounters a person in his or her field of view, the face is detected and recognized (if the person is not in the face database, the user can add it). The delivery of information comprises two steps: Firstly, the identity of the person is audibly communicated to the user (we are currently investigating the use of tactons [8] to convey identities through touch, but this is part of future work). Secondly, the location of the person is conveyed through a vibrotactile cue in the haptic belt, where the location of the vibration indicates the direction of the person and the duration of vibration indicates the distance between the person and the user. Based on user preference, this information can be repeatedly conveyed with every captured frame, or just when the direction or distance of the person has changed. The presence of multiple people in the visual field is not problematic as long as faces are not occluded and can be detected and recognized by the Social Interaction Assistant. We are currently investigating how to effectively and efficiently communicate non-verbal communication cues when the user is interacting with more than one person.

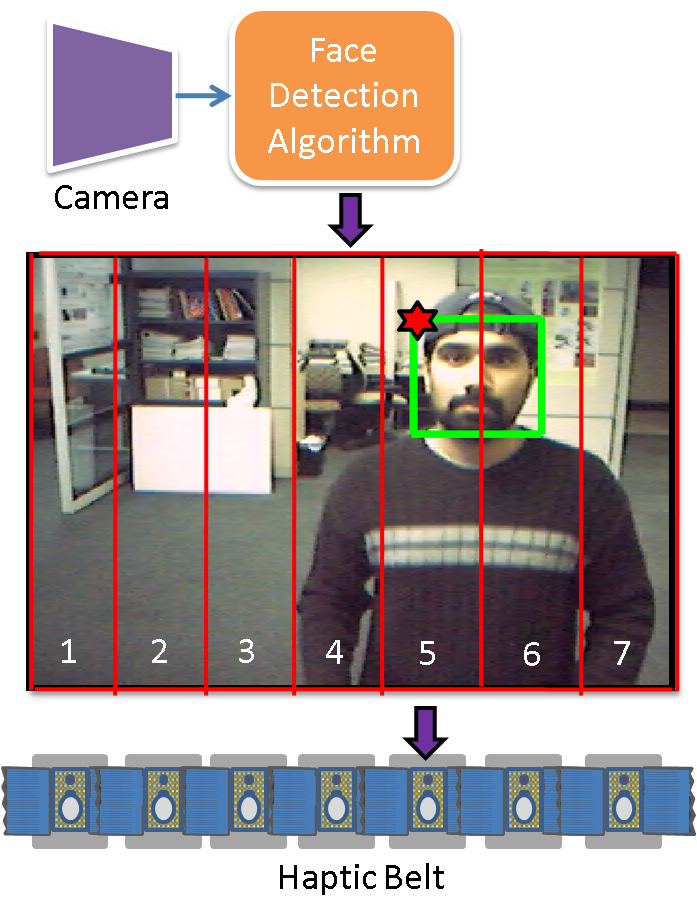


Figure 3: System Architecture for Haptic Belt used as part of the Social Interaction Assistant