**Title:**

HAPTIC GLOVE: VIBROTACTILE DELIVERY OF FACIAL EXPRESSIONS FOR PEOPLE WHO ARE BLIND

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**Project Summary:**

**Introduction and Motivation:**

Nonverbal communication cues make up nearly 65% of all human interpersonal communication. Unless the communication is being carried out remotely (through telephone, instant messenger, twitter etc), people tend to enrich their communication through the use of head and body positions or movements, referred to as communicative postures or gestures, respectively. Some of the head based communicative cues include head nod, head shake, head tilt, eye gaze, and facial expressions, while, the body based communicative cues include hand movements, hand and leg crossing, overall body posture, appearance and proxemics (how people use and perceive the physical space around them to convey social, personal and intimate emotions). Most part of such head and body based cues are visual in nature and people who are blind cannot independently access this visual information, putting them at a disadvantage in daily personal and professional social encounters.

Of all the visual nonverbal cues, facial expressions play a very important role. For example, during bilateral conversation, smiles can convey agreement while a single raised eyebrow can convey questioning. Very subtle movements on the facial features can convey rich and varied cues like desire, confusion, acceptance, anger, frustration, excitement, surprise, interest and even deception. Further, cultural artifacts of

For centuries, researchers have been studying human facial expressions and their impact on our everyday living. Consequently, individuals who are blind might be slow to respond or talk out of turn, possibly interrupting the conversation. To compound these problems, sighted individuals are often unaware of their non-verbal cues and often do not (or cannot) make appropriate adjustments when communicating with people who are blind. Also, people who are blind often do not feel comfortable asking others to interpret non-verbal information during social encounters because they do not want to burden friends and family. The combination of all these factors can lead people who are blind to become socially isolated [4], which is a major concern given the importance of social interaction.

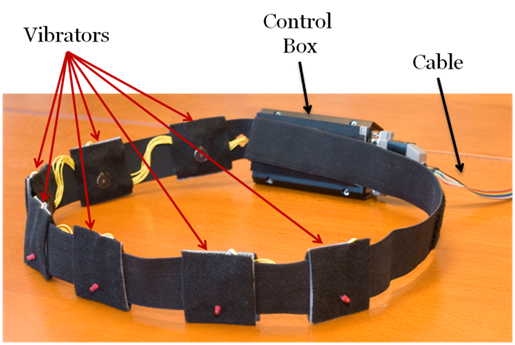
**Web Survey:**

We conducted an online survey of individuals who are blind or visually impaired to better understand their needs for support during social interactions [5]. We identified several key types of non-verbal information that people who are blind may need to access during social encounters: (1) the number of people standing in front of the individual , and where each person is standing; (2) where a person is directing his or her attention; (3) the identities of the people standing in front of the individual ; (4) the appearance of the people standing in front of the individual ; (5) whether the physical appearance of a person, whom the individual knew before, has changed since the last time he/she encountered him or her; (6) the facial expressions of the person standing in front of the individual ; (7) the hand gestures and body motions of the person standing in front of the individual ; and (8) if the individual’s personal mannerisms might not fit the behavioral norms and expectations of the sighted people in the interaction.

**Social Interaction Assistive Device:**

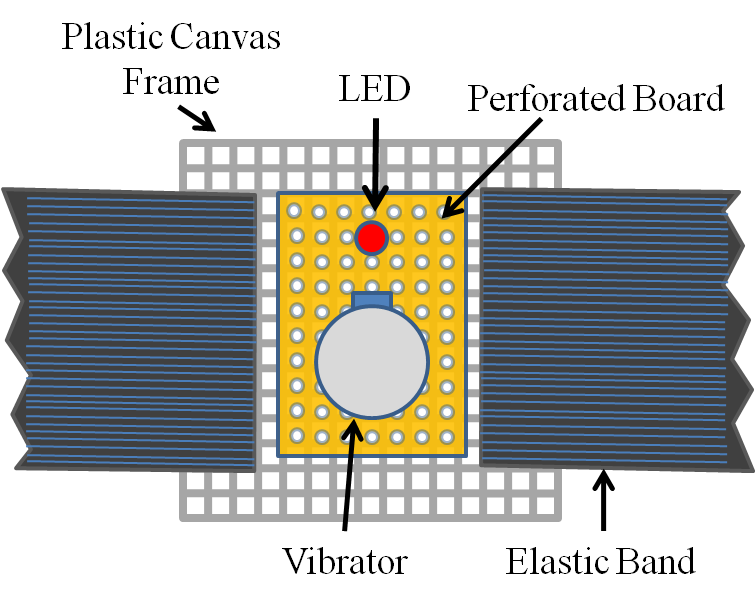
To cater to the social needs of the population who are blind and visually impaired, at CUbiC, we developed the Social Interaction Assistant [6]: a computer vision-based, wearable assistive device for individuals who are blind. The main components of this system include a pair of sunglasses with an embedded camera, a computing element, and a vibrotactile belt that can convey non-verbal communication cues to individuals who are blind or visually impaired. Specifically, we focus on the first non-verbal cue of helping users perceive the *number* of people in their visual field, and the relative *direction* and *distance* of each individual with respect to the user. When a person comes within the visual field of the camera, his or her face is located using rectangular filters found through adaptive boosting [7], and the extracted face image can optionally be sent to a recognition engine at the users request.

The haptic belt has 7 equidistantly spaced tactors in a semicircle such that inter-element spacing—when the elastic band of the belt is not stretched—is 3 inches, the center tactor is on the navel, and the two end tactors are on either sides of the waist. Figure 1 shows the prototype haptic belt, which is designed to be worn under regular clothing. A control box, used for managing the vibrations on the belt, is worn toward the user’s spine and a cable connects the control box to a laptop PC’s parallel port. Current work is aimed at enabling wireless connectivity between the control box and the computing element, which would significantly reduce the size of the control box.



**Figure 1:** *Accessible Caption*: Haptic Belt: The figure shows an elastic belt with 7 vibrators and a control box at one end with a PC parallel port cable connected to it. The details of the belt were explained in the text above.

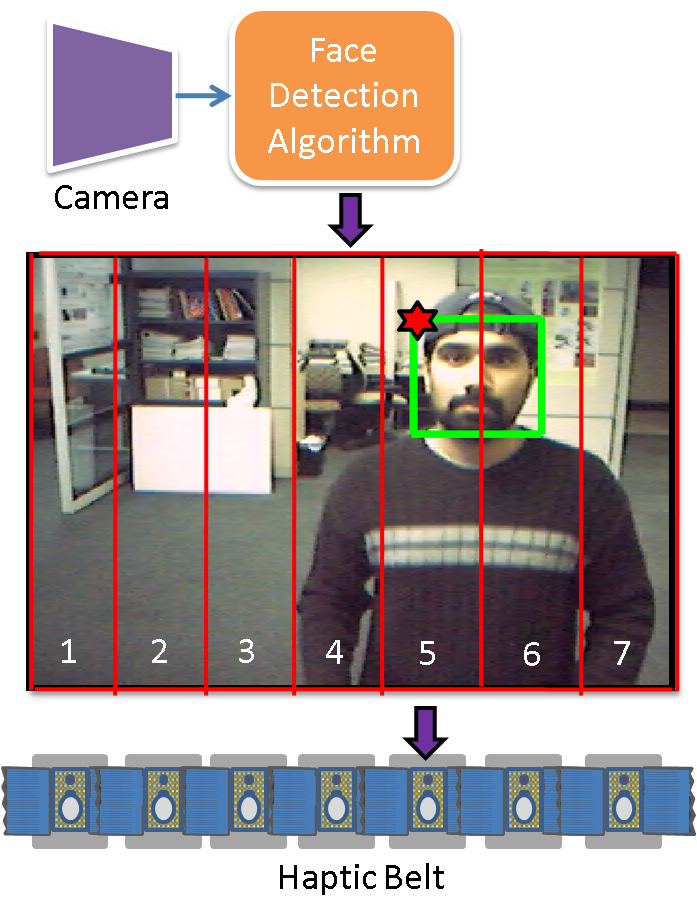
Figure 2 depicts the construction of each tactor on the belt. We used pancake cell phone vibratory motors which are installed on a perforated board along with an LED used as a visual indicator for debugging and testing. The perforated board itself was tied to a square piece of plastic canvas frame. The vibratory elements were joined with an elastic band that provides flexibility, ease of use and adaptability to different users. The motors themselves were connected using flexible multi stranded wires that allow for expansion and contraction of the belt around the waist. The control unit for the belt consisted of 7 opto-isolators controlled via 7 bits of a laptop PC’s parallel port. The actuation of the tactors is controlled through software that turns the bits of the parallel port high or low.



**Figure 2:** *Accessible Caption:* Individual Elements of the Haptic Belt: The figure shows the individual elements of the 7 vibrators on the belt. The complete description of these individual elements was provided in the paragraph above.

**Use Case Scenario:**

A person who is blind or visually impaired wears the glasses that has a camera discreetly built into the nose bridge (as described in [6]) and wears the haptic belt under their garments around the waist. The idea of the social interaction assistant is to communicate the location and distance of any person in front of the user using the position and duration of vibration on the belt. For now, only one person can be localized in front of the user; the one that is closest to the user. Figure 3 shows the device in action.



**Figure 3:** *Accessible Caption:* System architecture for haptic belt used as part of the Social Interaction Assistant: The figure depicts a camera as an input device followed by a Face Detection Algorithm module. The output of this module shows the image of a person with a green square box around the face. The green box represents the face detection output. This frame is divided into 7 regions corresponding to 7 vibrators on the haptic belt. The region where the top-left corner of the face box is located, decides which vibrator would indicate the location of person. The duration of vibration indicates the distance.

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