- Friday, March 4, 2005
  Touching without contact: The spatial environment sensed via vision

  The ability to perceive" the local and immediate environment for daily living activities is needed by all people. People with visual impairments require technology that identifies obstacles in their immediate path both inside and outside of buildings and assists in navigational tasks. Unanticipated factors such as construction work, garbage placement, poor weather, irregular traffic, other pedestrians and bicycles can make the basic challenge of navigating streets and sidewalks difficult. Improved obstacle detection and avoidance capabilities (that augment existing aids such as the long cane or guide dog) will support safe independent travel, increasing access to school, work and the community overall as well as increasing self-esteem and independence. It is estimated that approximately 180 million people worldwide have visual impairments of which 40 to 45% are blind (WHO).

  People with visual impairments lose their lives to pedestrian accidents far more frequently then their non-disabled peers. In the US (2001), almost 5,000 pedestrians died. Another 78,000 persons were injured while crossing the street, walking to school or waiting for a bus. A study (ACB) indicated that cars at intersections had hit 8% of visually impaired respondents while 28% reported that their white canes were run over by careless motorists. Sensory replacement and substitution techniques based on a camera system can provide valuable spatial wayfinding information for people that are blind or visually impaired when conveyed via an underutilized sense such as touch (haptics). Haptics is chosen over auditory in most circumstances so as to not jeopardize valuable environmental auditory information that is readily available. The intuitive use of a camera system as a replacement for original vision may well succeed where laser and sonar range finders have not in the past. It has been difficult to improve upon the long cane and guide dog because of their inherent economics, reliability and ease of use. Our focus for sensory substitution is wayfinding, in particular, providing medium distance information, up to10 m, that is beyond the reach of the long white cane while not addressing global positioning GPS. The visual to haptics sensory substitution problem can either be treated as an extraction (i.e., robot vision) and subsequent haptic mapping process or as a data compression process. A minimal spanning lexical spatial preposition set is used as an inspiration for obstacle avoidance mapping. Terrain haptic sensing lends itself better to a data compression manifold mapping. The key research questions include what information is crucial for extraction from the computer vision system, how much spatial information can be conveyed in tactile form and what is this mapping? The engineering challenge is to embed the system into an affordable, easy to learn, non-invasive, light, portable and wearable instantiation. We have developed our own low power and portable haptic devices of various embodiments and have explored electrical to mechanical energy transfer functions as well as perceptual responses, chiefly in terms of how much information content can be conveyed. Recently, we have developed a haptic controller with a MIDI interface for further explorations in haptic embodiments, chiefly vibrotactile in nature. Our work in obstacle avoidance has relied on acquiring depth (i.e., depth from stereo, optical flow divergence) while we have also investigated other visual routines for context recognition, face (object) detection, terrain modelling and visual SLAM (simultaneous localization and mapping). Preliminary experiments for predicting obstacle avoidance with people that are blind has received favourable responses and we have quantified the resulting trajectories and shown that they are strongly correlated with minimizing hitting probabilities. Our experiments have also revealed that building algorithms for robots and transference to an aid for a person that is blind is myopic and simplistic. A person that is blind is very perceptually responsive to the world via auditory, smell and even tactile wind patterns. For our work to succeed, our created haptic experience needs to assimilate what is spatial perception and in essence embody "the message as the medium".

  John S. Zelek
  University of Waterloo