Electronic Interfaces Aiding the Visually Impaired in Environmental Access, Mobility and Navigation

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Medical Electronics Division
Lodz – the second largest city in Poland

800 000 inhabitans
9 Universities
medical electronics (image and signal analysis), human computer interfaces, assistive technologies for the disabled

- electronic circuits and computed tomography
- telecommunication systems
Blindness

- **Lack of sight is a loss of 80-90% perceptual abilities, it affects other psychological functions**

- **Exclusion from social and professional life; poor education, low employment rate**

- **Dependence on others**
  - family, caregivers, guide dogs

- **1 mln visually impaired in Europe**
  - (approx. 80 000 in Poland), ageing demographics

- **Annual cost in the USA: 68 bln $**
Blindness
Day-to-day problems of the blind

I. Safe and independent travel
- avoiding obstacles and pedestrians
- detection of surface discontinuities (stairs, curbs...)
- avoiding collisions with vehicles
- avoiding robbery and thefts, ...

II. Navigation and orientation
- orientation and spatial awareness
- identification of geographical location

III. Access to information
- text, graphics, GUI’s (information society)
Mobility - “... the ability to travel safely, comfortably, gracefully, and independently”.

E. Foulke, The perceptual basis for mobility, 1971
Brambing’s model of mobility

Mobility of the visually impaired

Perception of objects
- Obstacle Detection
- Identification of Landmarks

Orientation
- Spatial orientation
- Geographical orientation
Mobility of the visually impaired

Perception and cognitive based
- Space perception
- Orientation
- Wayfinding

Action based
- Avoiding obstacles
- Walking
- Navigation
landmark

shoreline

obstacles
Primary mobility aids

**White cane** – used by almost all visually impaired

*Pros:* cheap, good in detecting surface obstacles, informs others

*Cons:* 100 hours of training, hand-held, does not protect head

**Guide dog** – used by less than <1% of the visually impaired

*Pros:* good in obstacle avoidance and following trained paths

*Cons:* very costly (~60 thousand USD), 6-years service

+ human guide

Leonard Cheshire Disability
Sensory substitution/supplementation

- **sight** (80-90% information about environment)
- **hearing**
- **touch**

Lower information capacity of non-visual senses

High level of concentration required

Braille Code
Hall’s extra-personal space

Panels

Far space

Near space

Person space

vision, touch, hearing, smell

vision, hearing

~1m

~4m
Electronic Travel Aids (ETA)

1. What information is needed?
- laser
- infrared
- ultrasound
- imaging
- RF
- GPS
- maps

2. Interface for presentation

3. Ergonomics

4. Training

Receptive field

Environment sensing & transducing

Processing

Nonvisual presentation interface
- Audio
- Haptics
Electronics Travel Aids (ETA)

1. What information is needed for the blind person?
   - non-cluttered but not omitting important information

2. Interface for nonvisual presentation
   - not masking other sounds, intuitive (less attention)

3. Ergonomics
   - size, weight, look

4. Training
   - important for efficient use
Kazimierz Noiszewski (1859–1930)

- professor of ophthalmology deviced an original method for cornea transplantation (1921)
- constructed **electroftalm** (an artificial eye), a device converting light energy into auditory or tactile stimuli (1889)

Ophthalmology Clinic
Warsaw Medical Academy
Electronic mobility aids (I)

„Extension of cane functions“:
- simple construction,
- limited (point like) field of detecting obstacles

LaserCane, UltraCane, SonarCane, Teletact
Electronic mobility aids (II)

*Environmental imagers:*
- complex
- expensive
- information overflow

*SonicGuide, vOICe, Navbelt, Virtual Acoustic Environment*
Espacio acustico virtual

Universidad de la Laguna - Tenerife

Each point is the source of a virtual sound
**Auditory scene display**

- **Stereovision**
- **Segmented 3D scene**
- **3D audio**
Real scene $\rightarrow$ scene model $\rightarrow$ obstacles
Auditory display concepts
Depth scanning

- Inspired by sonar
- Sounds code objects’ geometry and location
Acoustic model of the human head

Measurement of Head Related Transfer Functions (HRTF)
**Spatial sound space - HRTF**

<table>
<thead>
<tr>
<th>Moving sources</th>
<th>Real sound sources</th>
<th>Virtual sound source</th>
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<tbody>
<tr>
<td></td>
<td>3.1°</td>
<td>8.1°</td>
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System hardware

2007

2009

2010

20??
Orientation & navigation systems

1. Embedded infrastructures
2. GPS navigation systems
3. Teleassistance systems
4. Urban travel aids
Embedded infrastructures

TalkingSigns - USA
GPS-based systems

- BrailleNote
- EasyWalk
- Trekker
- Navigator
Urban travel aids

The NOPPA system - Finland
Teleassistance systems

- microphone
- earphone
- fish-eye lens camera
- GPS
- laptop

- Video
- GPS
- Audio

Digital map
Video stream
Headset
System trials
Operator’s terminal

- Digital map with the position of the blind user
- Video images from the blind user’s camera
- High resolution screenshot for text
Remote navigation system (v.3)
Integration of functions

Stereovision, video

Digital terrain map

GPS

GIS

Integration of functions
Smartphone for the visually impaired

Symbian smartphone assisting the blind:
- phone functions
- speech synthesis
- GPS navigation
- colour recognition
Reading signs
Visual prothesis

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2 mm
Instead of asking:

“How can this technology be adapted to the blind user?”

we want to ask:

“What information is actually needed by a visually impaired traveller and how it should be presented to him/her?”.

Smith-Kettlewell Eye Research Institute
Acknowledgements

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Long-term vision loss

The blind who recovered sight:
- recognise: motion and colours
- do not recognise: shapes, faces, objects
- false depth perception

Cause:
plasticity of nerve cells

R. Kurson, „Crashing through: a true story of risk, adventure and the man who dared to see”, Random House Inc., 2007
Outlook