Assistive Technologies for Mobility

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Mobility, Humans, and Machines

Today

Assist Blind | *Coop. Mobility* | *Intelligent Wheelchair* | *TAO-7* | *Robot*

Sensing

Control

Human

Assistance for the Blind

Statistics

- *Blind and visually impaired*
  - *~10 million people in the U.S. (3%)*
  - *~1/2 are elderly*
- *Legally blind (20/200)*
  - *~1.4 million people in the U.S.*
  - *~1/3 are children*

(American Foundation for the Blind)

Mobility, Orientation, and Wayfinding

- *Mobility*

  Getting around while avoiding obstacles

- *Orientation*

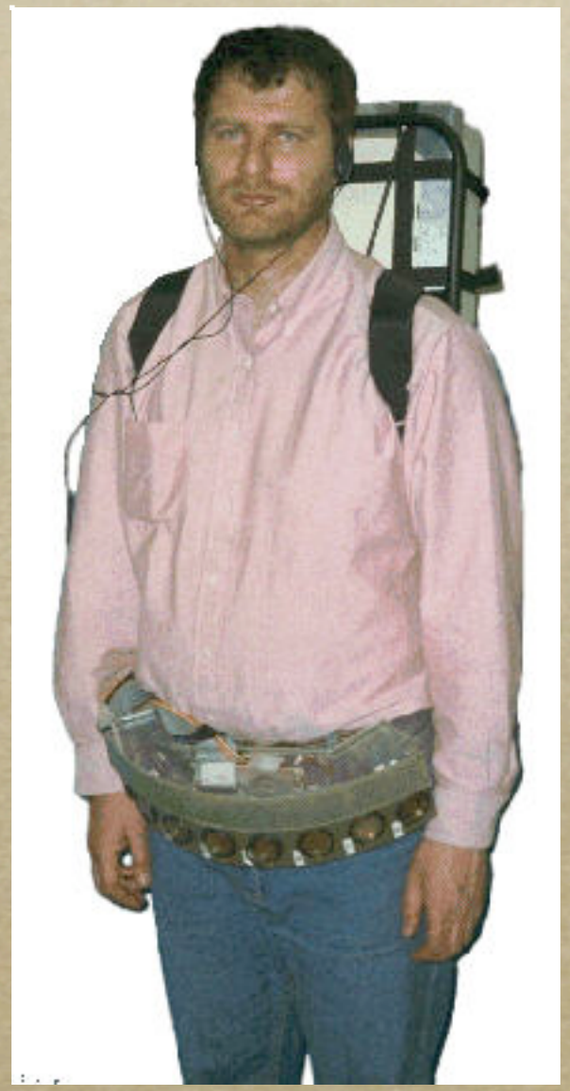
  Establish and maintain awareness of position relative to landmarks and/or destination

- *Wayfinding*

  Employ spatial orientation to reach a destination—sensing, orienting, and navigating

NavBelt

- *Aimed at mobility*
- *Shoval, Borenstein, and Koren (1994)*
- *Computer & ultrasonic sensors*
  - *Obstacle detection and avoidance*
  - *Binaural audio feedback to user*
- *Three modes*
  - *Guide—stereo acoustic steering*
  - *Image—an "acoustic panorama"*
  - *Directional Guidance—relative to user-selected target*
- *Difficult to use...led to GuideCane...*



Talking Signs

- *Aimed at orientation*
- *IR transmitters mark important objects in environment*
- *Handheld receiver senses, decodes, speaks*
- *Applications*
  - *Is that my bus?*
  - *Street crossing*
  - *Starbucks*
- *Lots of installations*

http://www.talkingsigns.com

Personal Guidance System

- *Aimed at orientation and wayfinding*
- *Jack Loomis et al. (1994)*
- *Goals*
  - *Self-contained navigation*
  - *Improve spatial orientation*
  - *<u>Not</u> obstacle avoidance*
- *Components*
  - *DGPS and fluxgate compass (head-back)*
  - *486 Computer with GIS database*
  - *Keyboard and spatial audio display...*

Auditory Display for the Blind

- *Loomis, Golledge, and Lkatzky (1998)*
- *Evaluation of four display modes*
  - *Virtual—compass on head; spatial stereo speech identifying landmark; volume; head-motion parallax*
  - *Left/Right—compass on backpack; "left," "right," "straight;"*
  - *Bearing—similar to L/R; "straight" and heading in 10° increments*
  - *No compass—successive DGPS; user had to keep moving!*

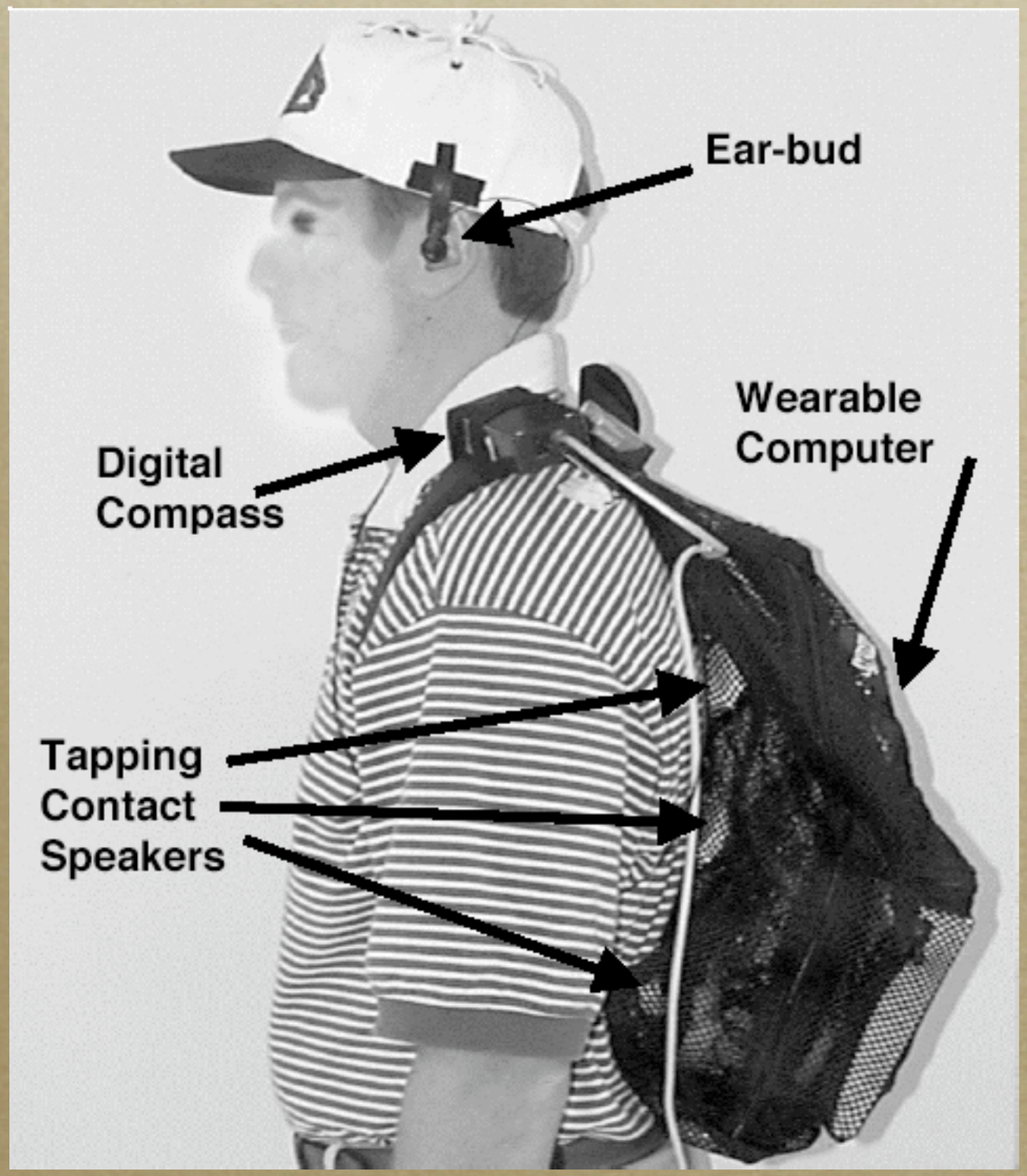
Wearable Interfaces for Orientation and Wayfinding

- *Ross and Blasch (2000)*
- *"Environmental flow"*
  - *Sounds, smells, temperatures, proprioceptive and vestibular senses*
  - *Degradation in the elderly*
- *Objectives*
  - *Evaluate three different interfaces*
  - *Compare head vs. body reference*
- *Street crossing—tendency to veer*

Configurations

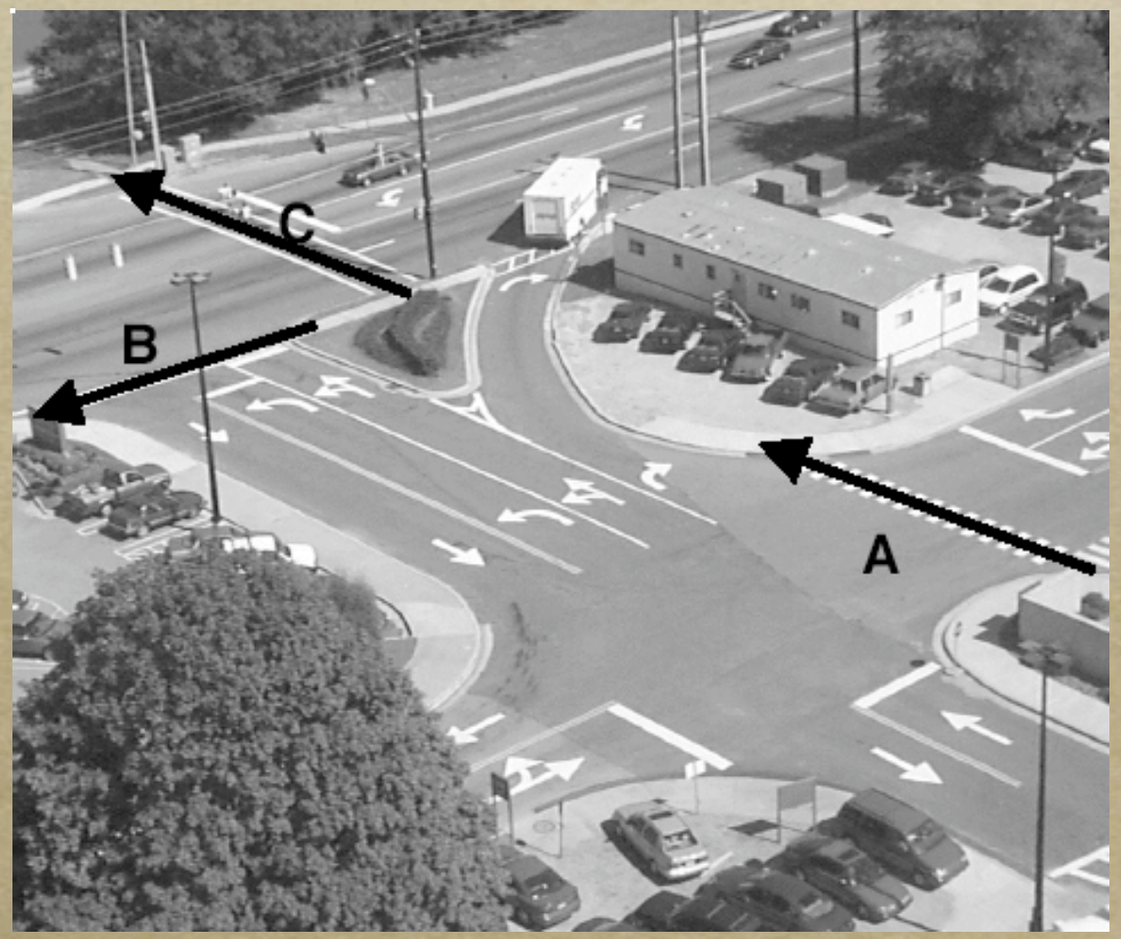
- *Three display modes*
  - *Sonic "carrot"—stereo tone guides toward landmark; ~Loomis "Virtual"*
  - *Speech interface—mono clock-based announcements; ~Loomis "Bearing"*
  - *Shoulder tapping device—3x3 then 3x1 "thumper" array on back; ~Loomis L/R*
- *Two orientation sensing locations*
  - *Head or backpack*

Apparatus


Ear-bud
Wearable
Computer
Digital
Compass
Tapping
Contact
Speakers

Street Crossing (Task)

- *Typical—detect curb; orient; wait; walk straight*
- *Traffic sounds help or confuse*
- *More difficult these days w/ curb ramps*
- *Atlanta VA Medical Center, three intersections*



Experiment

- *15 test subjects*
  - *62–80 (average 68)*
  - *Half legally blind*
    - *Four had hearing problems*
- *Each crossing at intersections A, B, and C*
- *Each interface and sensor (random)*
- *Canes but no guide dogs*
- *Pre (training) and post (control)*

Results

- *Tapping won, "carrot" close*
  - *Tapping/body—highest performance and preference*
  - *"Carrot"/body—high preference but lower performance*
  - *"Carrot"/head—high performance but lower preference*
- *Tests with "best" device*
  - *No improvement in pace*
  - *~1/3 veering (baseline)*

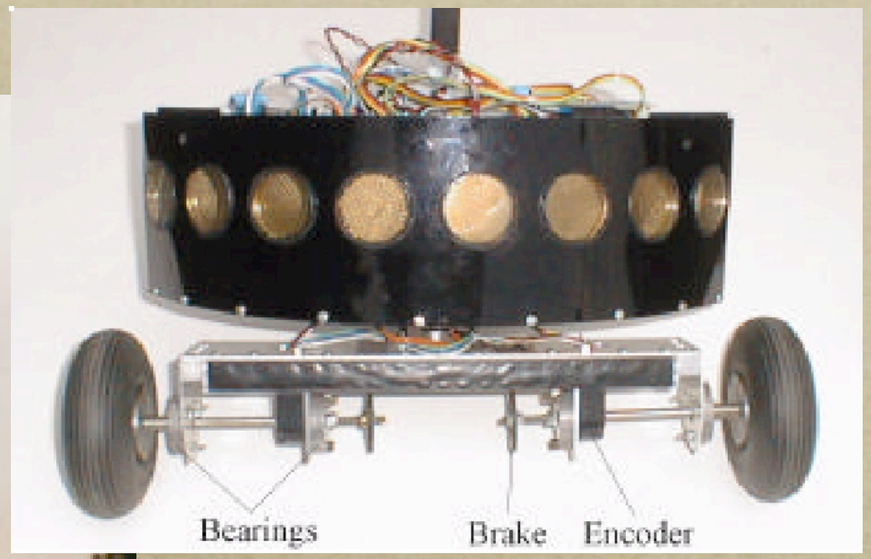
Constructive Exploration

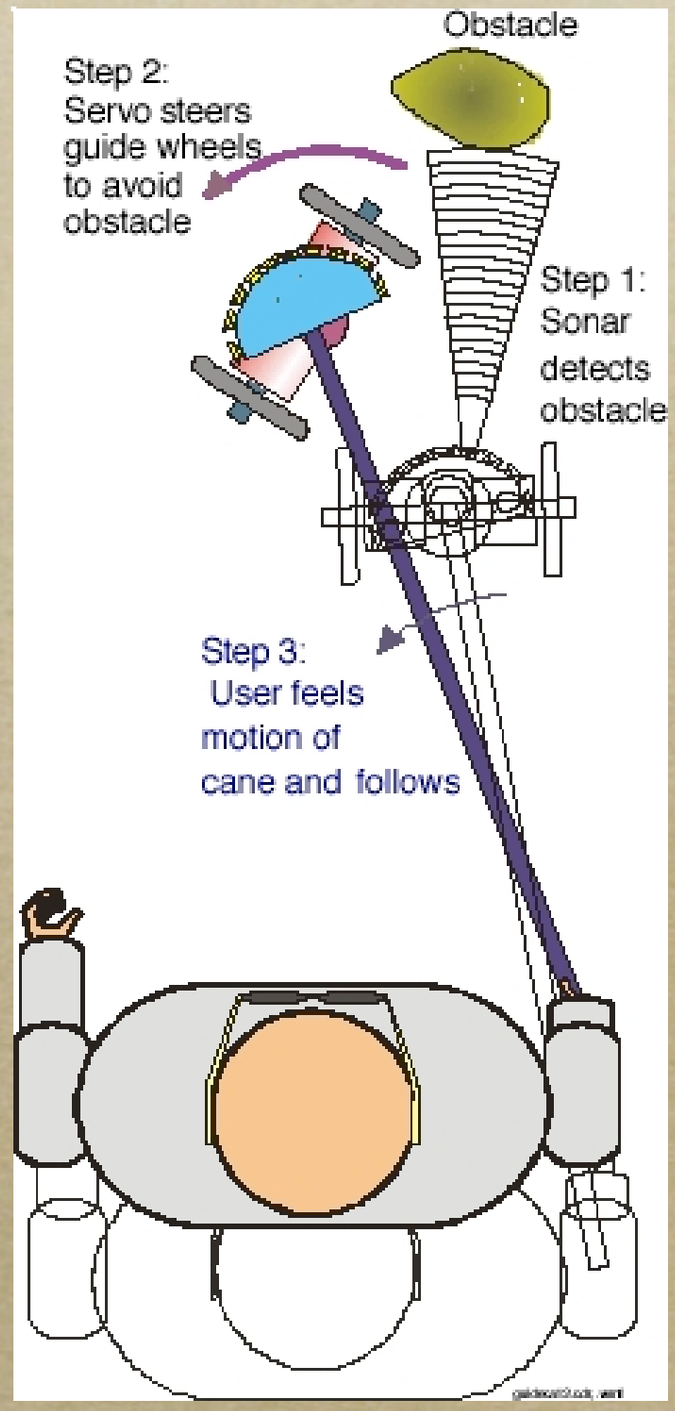
- *Schneider and Strothotte (2000)*
- *Application of "learn by doing"*
  - *Users construct a model of the route*
    - *Block (~long legos)*
    - *Guided by computer vision or haptic feedback device*

Cooperative Mobility

Guide as opposed to transport

GuideCane (UMich)





Effective Shared Control in Cooperative Mobility Aids

- *Wasson et al. (2000)*
- *Intelligent wheeled walker*
  - *No propulsion*
  - *Braking and steering*
- *Hard problem*
  - *Guide and support*
  - *Human + robotic control*
  - *Guidance == expectations*

- *Walkers are used more than any mobility aid other than the cane (National Center for Health Statistics, 1994)*

System Components

- *Devices*
  - *Sonar, infrared, wheel encoders*
  - *Infrared laser scanner*
- *Multiple control systems*
  - *Warning system only—vibrating handle*
  - *Safety braking only—1/d and braked*
  - *Safety braking + steering—1/d, timeout*
  - *Path following—control w/o obstacles*

Intelligent Wheelchairs

Goals (Objectives)

- *Transportation*
- *Obstacle avoidance or accommodation*
- *Robustness to failure (fault tolerant) and graceful degradation*
- *Sociability and flexibility*
- *Advanced features*
  - *Tracking (monitor user)*
  - *Automative transportation....*

The iBot 3000 (Dean Kamen)

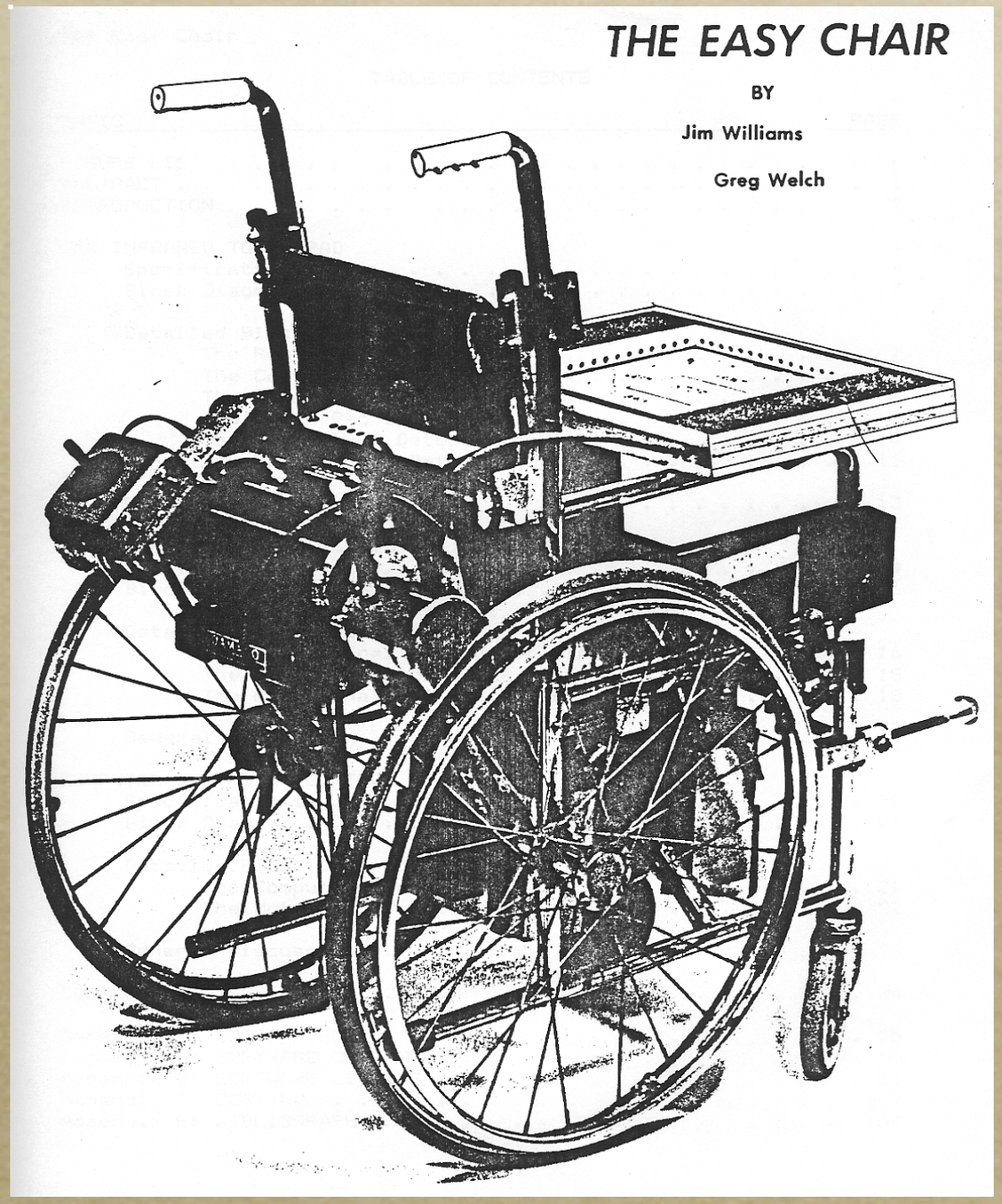
NavChair (1990-1995)

- *Simon Levine (Director of Physical Rehabilitation at the University of Michigan Hospital)*
- *Intended for users with sensory, perceptual, or motor impairments*
- *Avoid obstacles, follow walls, and travel safely*
- *Vector Field Histogram Object Avoidance (2D histogram with polar evaluation)*


Navchair79.jpg, 05/01/93

The EasyChair (1985-1986)

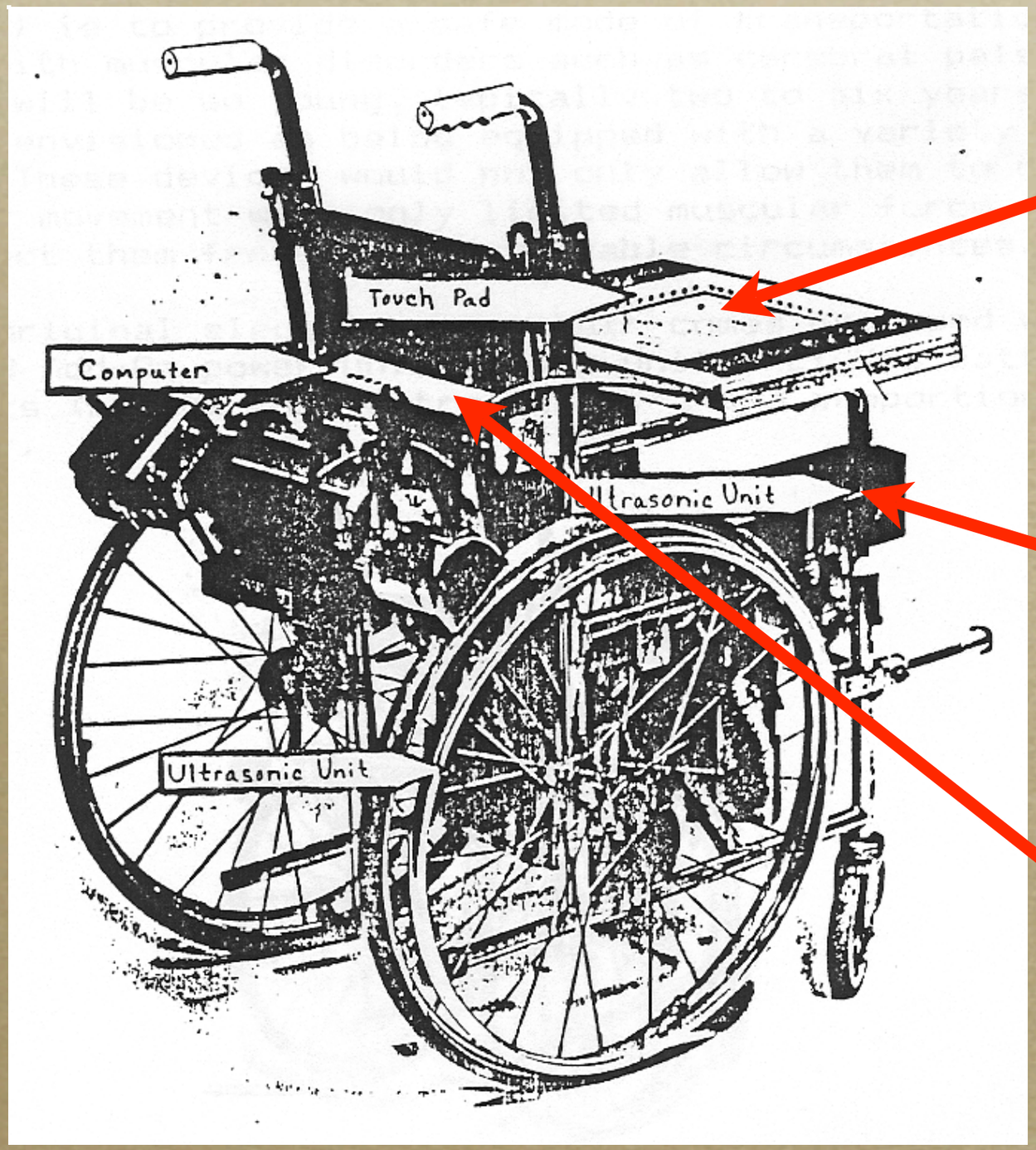
- *Prof. George Karlin*
  - *Purdue University*
  - *Wabash Center*
- *Intended for 2-6 year old children with muscular disorders (cerebral palsy)*
- *Williams and Welch's Senior Design Project*
  - *Electrical Engineering Technology*
  - *Outstanding Project*

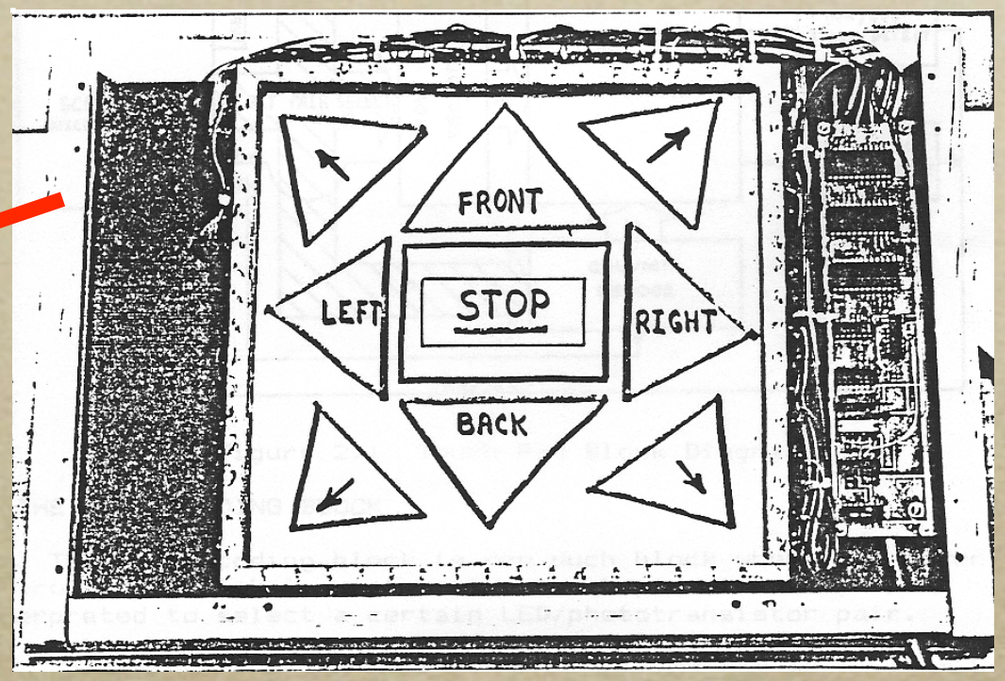


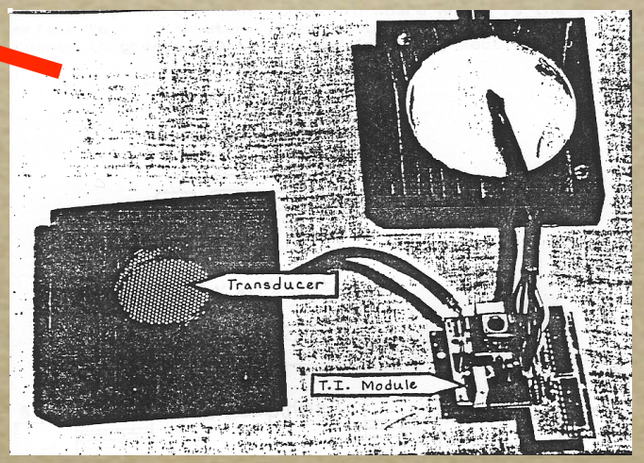
Motivation

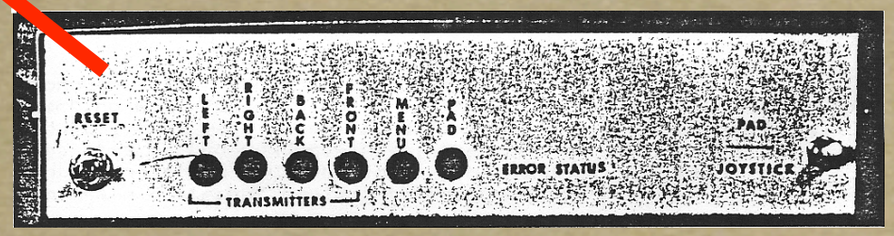
- *Children with muscular disorders*
  - *Limited opportunities to acquire experience with mobility...*
  - *...limits opportunities to initiate communication with others...*
  - *...limits their learning capabilities.*

The System

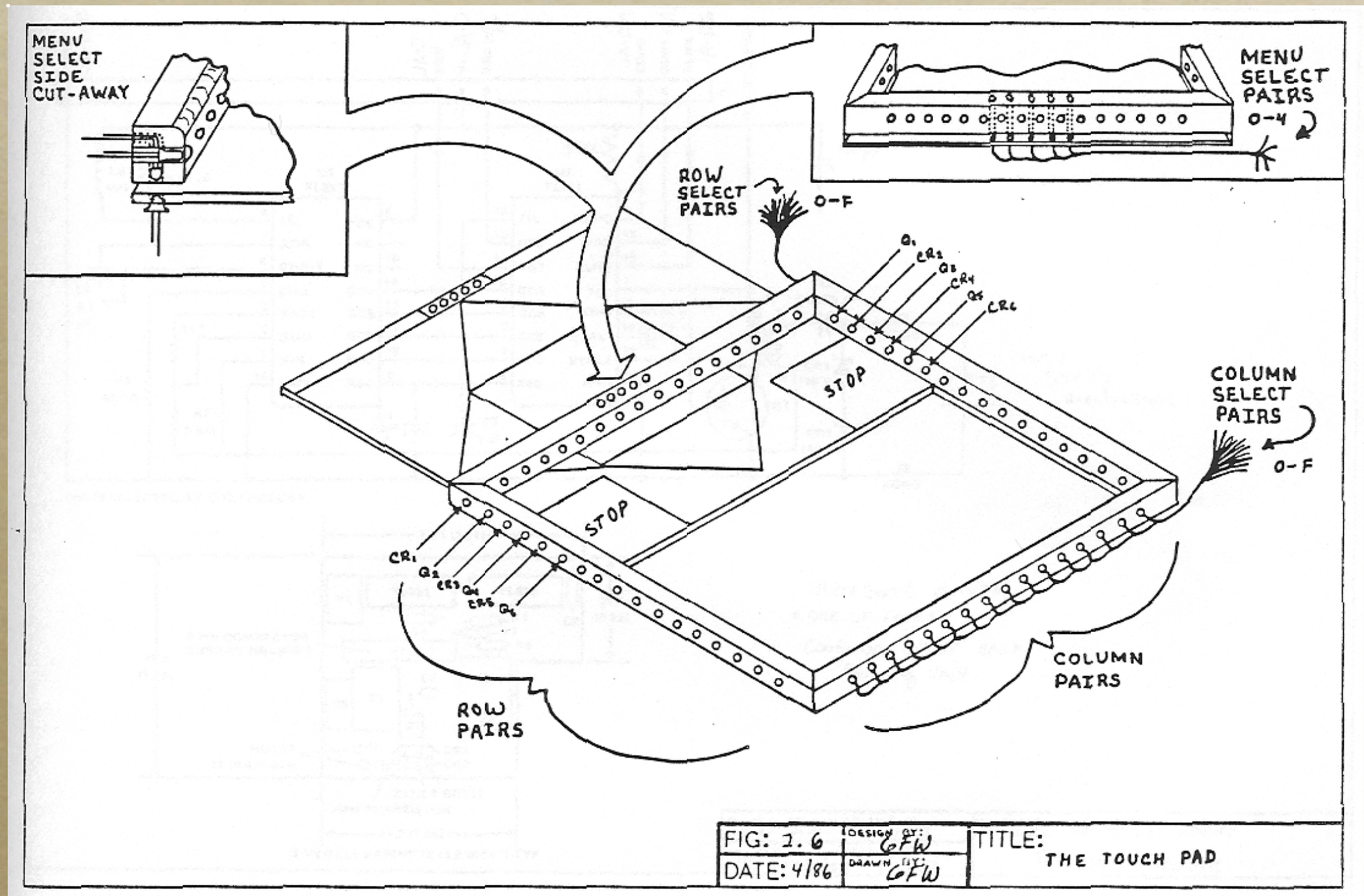

Touch Pad
Computer
Ultrasonic Unit
Ultrasonic Unit


FRONT
LEFT
STOP
RIGHT
BACK


Transducer
T.I. Module


RESET
LEFT
RIGHT
BACK
FRONT
MENU
PAD
TRANSMITTERS
ERROR STATUS
PAD
JOYSTICK

The Touch Pad (Input)



Tao-1...7 (Applied AI Systems)

From their literature

- *Uses active infrared and ultrasonic sensors for obstacle avoidance and maneuvering in complex environments*
- *Autonomous mobile platform using behavior-based AI (New AI) techniques*
- *Seemless [sic] manual override with original joystick control*
- *Free-space detection and landmark-based navigation using optional vision systems*
- *Behavior control by voice using optional voice recognition interface*
- *Generation of voice outputs from behaviors using optional voice synthesis interface*
- *Comes with basic behavior set using inputs from standard sensors*
- *Open design for easy addition of user options in hardware/software*
- *User's own behaviors easily developed using C language and GNU-C compiler*

The End

http://www.cs.unc.edu/~welch/class/mobility/