Natural Interactive Walking

Research Update

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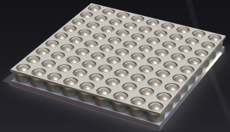
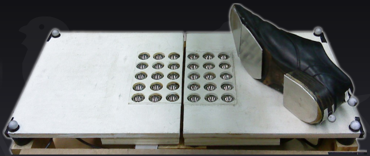
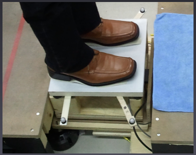
Variable-friction plate design

- Goal: display variable-friction ground surfaces, in particular slippery grounds
- Context: immersive virtual reality, slips-related research
- Solutions investigated: slippery plate with friction added
  - with rolling elements (ball transfer units)





  - with slippery materials (Teflon, UHMW polyethylene)



Variable-friction plate design

Pros and cons of rollings elements / slippery covers, from our tests

+ Lower static friction: 0.025 ± 0.005 / 0.11 ± 0.01 (ice: $\sim$0.02)
– Uneven surface: limits the footwear and the simulation of heel strike
– Reflective balls: limits the visual display
– Noise from rolling elements: limits the vibrotatile display

Future work: Investigate a device combining slippery and high-friction materials

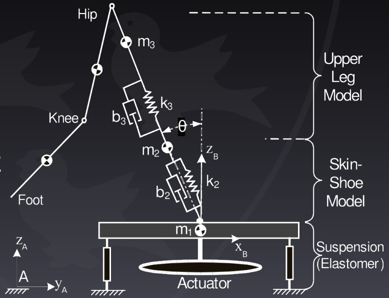
Spectral compensation for vibrotactile transparency

Problem: vibrotactile transparency of our tile limited by the structural properties of its components:

- suspensions under each corner (influence of the user's weight and location on the tile)
- actuator fidelity
- variable-friction mechanism

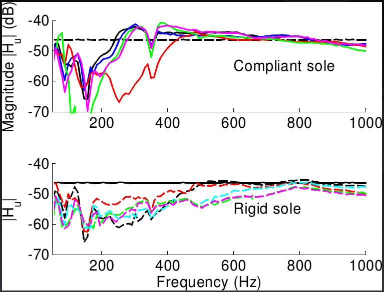
Goal: flat response from 20 to 1000 Hz

Solution: compensation algorithm based on an FFT filter-bank and a rheological limb model



Spectral compensation for transparency

- Measurements of frequency response with 10 users with compliant or rigid soles



- Compensation algorithm

Spectral compensation for transparency

- Measurements of frequency response with 10 users with compliant or rigid soles
- Compensation algorithm

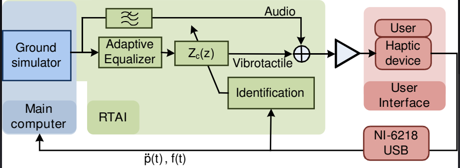
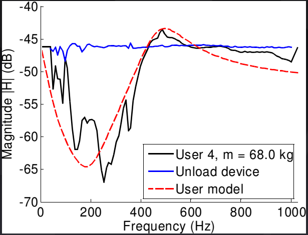


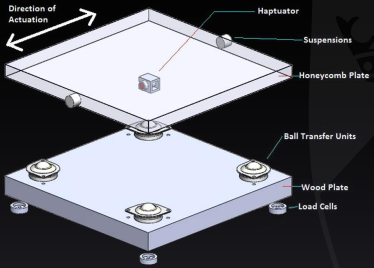
Figure: Vibrotactile compensation algorithm

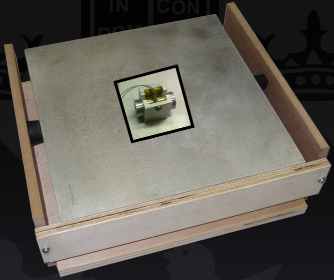


Parameters of the user's lower limb identified from the frequency response $\rightarrow Z_c$ function

Future work: identification algorithm (neural networks) and compensation for the influence of the user's position on the tile

Tangentially-actuated vibrotactile tile





- Advantages of tangential actuation
  - Higher vertical stiffness
  - Larger frequency bandwidth
  - Better transparency according to the user's location
  - Lower profile
- Performance tests in process
- Results to be submitted to IROS 2011

Foot Based Geospatial Navigation

Figure: Overview of Geospatial Navigation System

Foot Based Geospatial Navigation

Motivating factors:

- Appropriate task for foot control.
- Immersive approach to navigating rich spatialized data.
- Multitasking opportunities.
  - Meta-data manipulation using hands.
  - Crisis management.
  - Urban design and planning.

Foot Based Geospatial Navigation

Novel elements:

- Coupling with floor projection; affords context to gestures.
- Large interactive foot surface; affords larger gestures.
- Use of temporal force gestures.

Foot Based Geospatial Navigation

Preliminary experiment recently completed:

- Within-participants experiment, all ordering permutation.
- 12 participants.
- 7 tasks per modality.
- Users must navigate to a target destination and answer a street view related question.
- Quantitative – completion time – and qualitative – post experiment questionnaire – feedback

Foot Based Geospatial Navigation

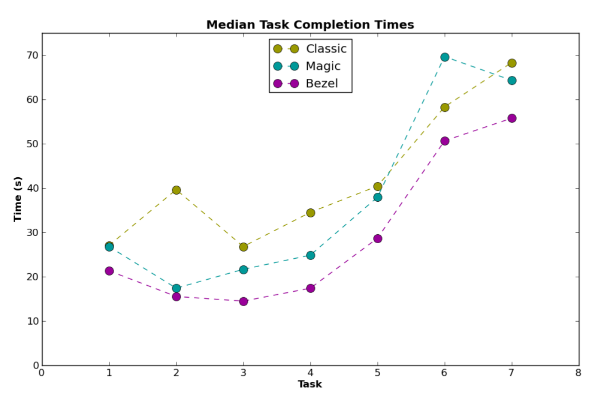


Figure: Median Task Execution Time by Modality

Foot Based Geospatial Navigation

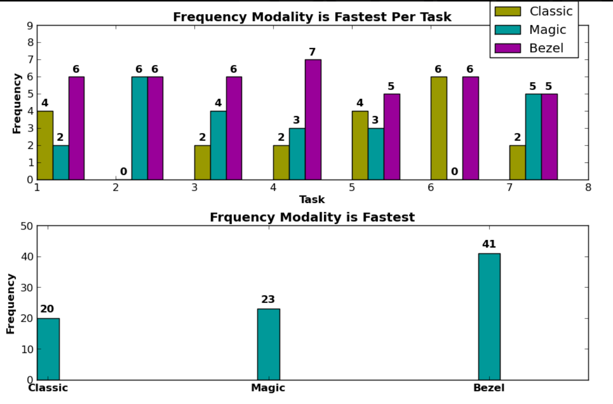


Figure: Frequency of Fastest Execution Time by Modality

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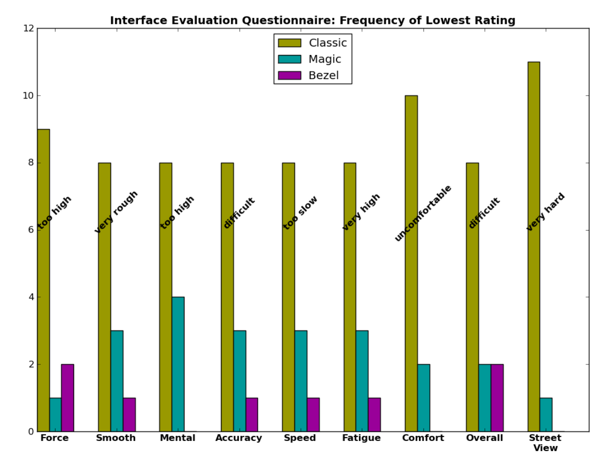

Figure: Frequency of Worst Relative Rating, Likert Scale

Gait Adaptation Experiment

- Goal: evaluate the multimodal floor experience, in particular its impact on gait adaptation
- Experiment Design:
  - Procedure: participants walk from non-actuated tiles to actuated tiles, 5-10 times per ground surface. Number of steps on the actuated surface limited to a full stride (about 2 steps)
  - Measurements: the normal force, the centre of pressure and parameters of motion with motion capture compared to walking on non-actuated ground
  - Ground surfaces: ice, sand, snow, water
- Status: work in progress

Recent dissemination

- Y. Visell, B. Giordano, G. Millet, J. Cooperstock, Vibration Influences Haptic Perception of Surface Compliance During Walking. To appear in *PlosOne*, 2011.
- M. Otis, G. Millet, S. Beniak, J. Cooperstock, Modeling of Lower Limbs for Vibrotactile Compensation. To appear in *Proc. of the 34th Canadian Medical and Biological Engineering Society Conference (CMBEC34)*, 2011.
- G. Millet, M. Otis, G. Chaw, J. Cooperstock, Initial Development of a Variable-Friction Floor Surface. To appear in *Proc. of the 34th Canadian Medical and Biological Engineering Society Conference (CMBEC34)*, 2011.

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