New ways to design haptic interactions

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Syria
Tunisia
Afghanistan
Morocco
Iraq
Iran
Pakistan
East China Sea
Algeria
Libya
Egypt
Nepal
Western Sahara
Saudi Arabia
India
Myanmar (Burma)
Oman
Mauritania
Mali
Niger
Sudan
Yemen
Thailand
South China Sea
Chad
Bay of Bengal
Burkina Faso
Gulf of Aden
Arabian Sea
Vietnam
Philippines
Guinea
Nigeria
Andaman Sea
Ethiopia
Ghana
South Sudan
Laccadive Sea

Multimodal interaction

Key area of research is *Multimodality*

More human way to work

- Not everyone has all senses / control capabilities
- May not always be available all of the time

No one sense can do everything on its own

Using other senses/control capabilities to design new forms of interaction

Research areas

Novel multimodal interaction techniques

Touchscreen and mobile user interfaces

Wearable devices

In-car interactions

Shared use of TV and phone/tablet

User interfaces for cameras

Accessibility

- Blind users and visualisation, Older adults, navigation, mobility
- Multimodal home care

Mobile health apps

Modalities

Non-speech audio

- Earcons, 3D sound, sonification, Musicons

Computer haptics

- Force-feedback, pressure input, temperature output
- Tactile (vibrotactile and pin arrays), ultrasound
- Tactons

Gestural interaction

- On-screen, with device, in-air

Smell

What is haptics?

Haptics

Sense and/or motor activity based in the skin, muscles, joints and tendons

Two parts:

Kinaesthesia: Sense and motor activity based in the muscles, joints and tendons

Cutaneous/(touch): Sense based on receptors in the skin

ISO standard 9241-910 Tactile/Haptic interaction

Overview

Haptics has great potential but …

- Difficult to design good haptic interactions
- Devices don’t match human capabilities

How can we make better haptic interactions?

- Need to think about it differently
- Try different aspects of touch

- Pressure input
- Thermal output

Haptics

Over the years I have studied haptic interaction in many different settings with many different devices

Many different frustrations …


Wrist Tilt Menu
File
Edit
Search
View
Settings
Window
NOKIA
stracter Range
SPRAWL

But there are always problems

Devices have significant limitations

- Hardware
- Software
- Mismatch between human capabilities and devices

Hard to create ‘real’ experiences

- Force feedback devices always feel spongy, hard to do torque forces
- Vibrotactile devices just feel like …. vibrotactile devices

Solutions?

Use aspects of touch for which we have good sensing or actuation

- Pressure input
- Thermal feedback

Rich human experiences

Hardware/software available now

Little research to guide design

PRESSURE

Pressure input

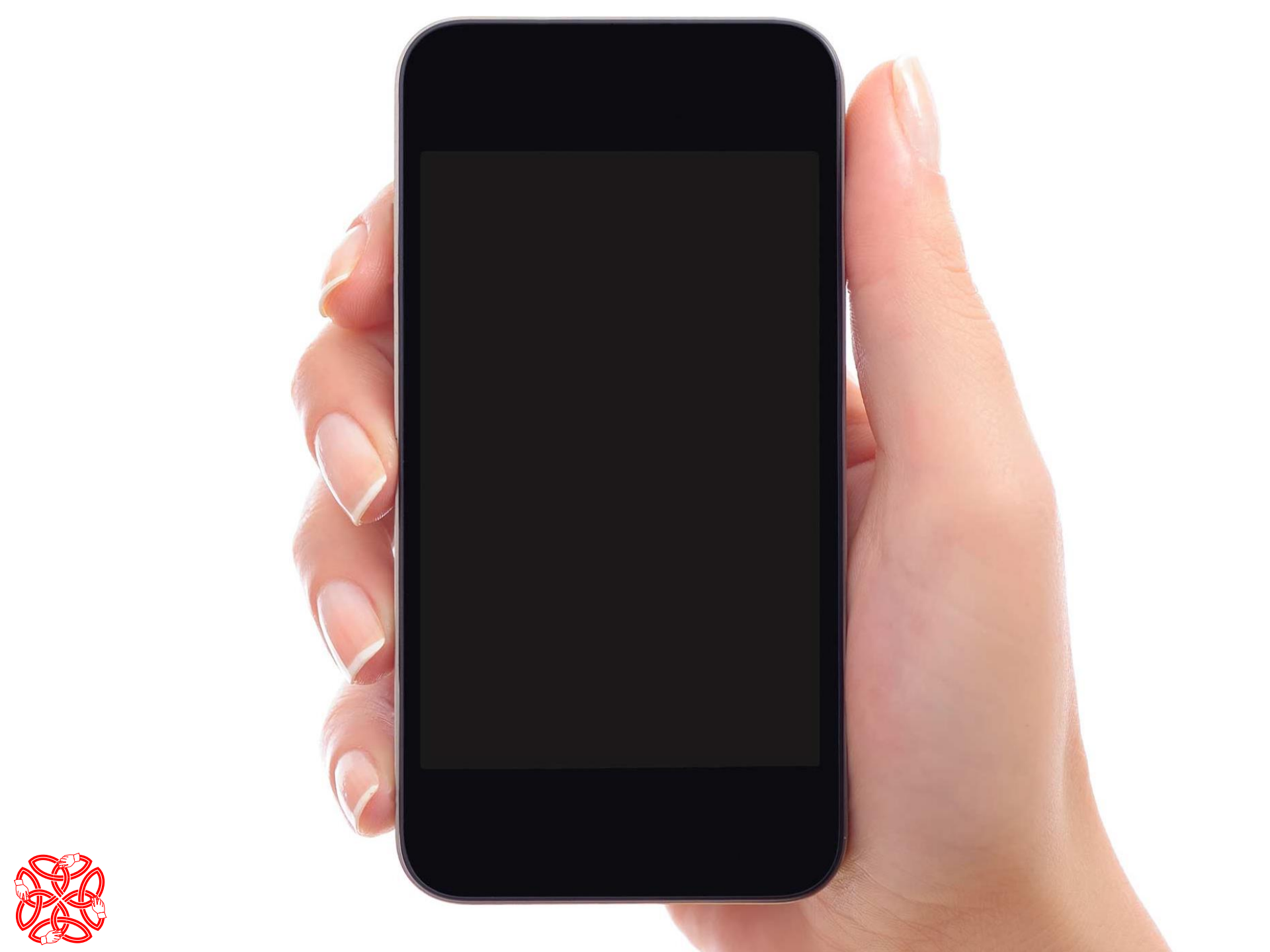
Little studied in HCI, but a rich source of input and control

- Musical instruments
- Drawing (graphics tablet), holding / grasping

Can we uses pressure as another input mechanism?

No need for spatial positioning of finger

- Easy to do ‘eyes free’
- Can use the z-axis
- Does not require change of grip, allows interaction while gripping



Pressure

Pressure sensing does not require manipulation of angle of the device

- Unlike accelerometers or gyroscopes for tilt control

Pressure can be distributed over a large area meaning it can be accessed using multiple postures

Hardware

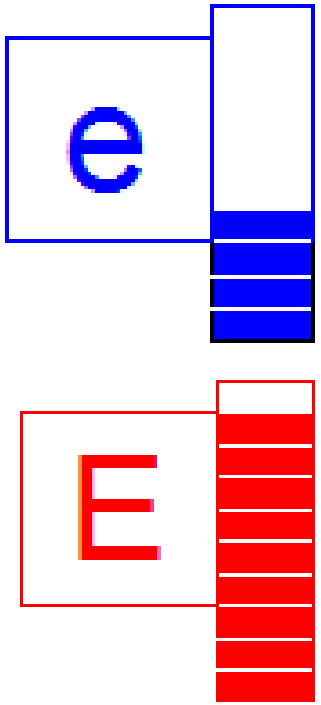
Many types

We use force sensing resistors

- Thin
- Flexible
- Cheap

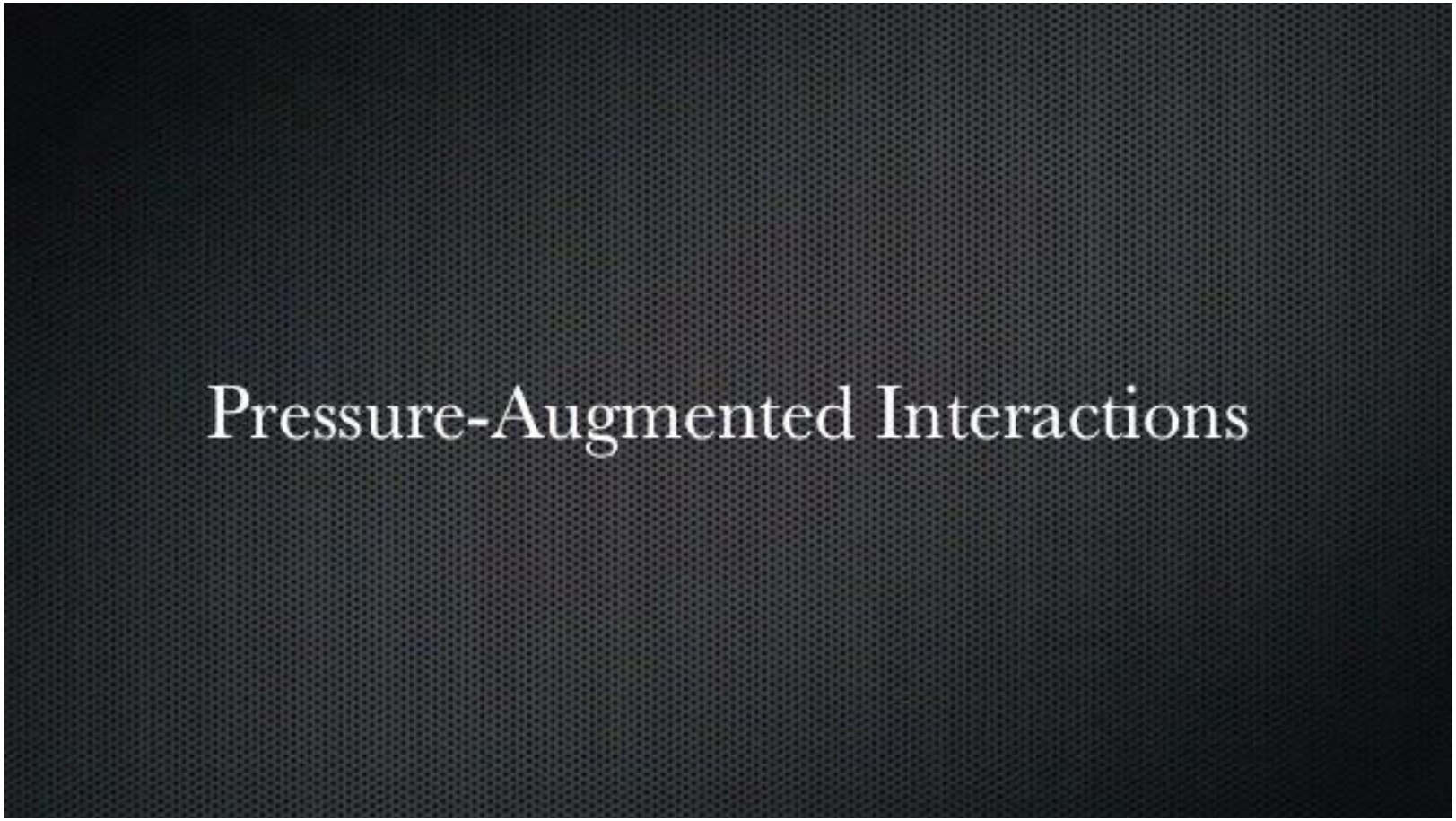
First attempt: Pressure input

- Pressure keyboard on standard Nokia N800
  - Light press = lower case,
    Hard press = upper case
  - Good for entering mixed case text, punctuation, emoticons, function keys, ...
- Graphical pressure meter
  - Dynamic feedback
- Tested users sitting and walking
  - Pressure can be as fast as regular keyboard
  - Lower error rate, especially when mobile



Pressure keyboard

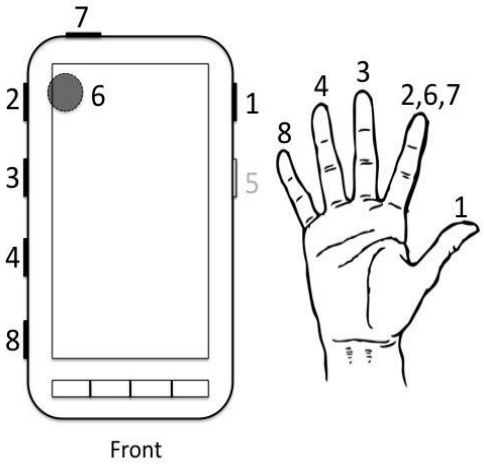
Other pressure interactions



Grip and grasp

Can we use the way we grip a device to control it?

- Can we use this for interaction?
- Make a two-handed interaction into a one handed version



Grip results

Compared rotate and zoom

- Pinch/rotate using multitouch and 2 hands
- Grip

One handed grip equal to or better than traditional method

- No finger occlusions
- Works well for non-visual input as fingers don’t need to move
- Also works well when walking

Squeezing devices very effective for input

Pressure for two-handed input

Pressure can be used in other situations

- Phone or tablet

Non-dominant hand supporting device

- Cannot move
- But could provide pressure input

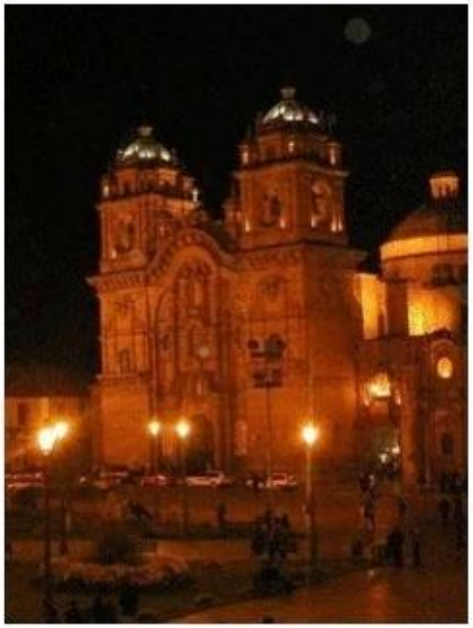
Pressure and dial input

Separated scrolling speed from scrolling direction

- Direction was dominant hand (DH)
- Speed was non-dominant hand (NDH)
  - Accelerator

Pressure Sensor

Physical Dial



Results

Pressure was successful

- Users could control it well while using the dial

Accelerator model worked well

- Easy to make small movements
- Pressure to increase scrolling speed – very natural

FineTuner

Problems with pressure

Selection is always difficult using pressure

- Quick Release
- Dwell

QR

- Difficult to detect reliably

Dwell

- Slows interaction down

Selection event often does feel natural

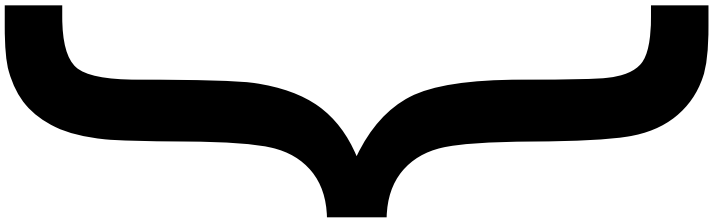
Pressure input is transient

Natural Inverse

intrinsic inverse action that produces an opposite effect

Bounce-Back

returns to its initial state soon after the user has relinquished control



Transient

natural inverse occurs automatically whenever control is released

Transient pressure

Can users operate pressure input without having a negative effect on dominant hand interactions?

Targeting

- How accurately can users a provide two-handed combination of pressure and touch input

Maintaining

- How accurately can users maintain different levels of pressure during a bimanual interaction


Transient and Transitional States
Pressure as an Auxiliary Input Modality for Bimanual Interaction

Targeting study

Single crosshair appeared on the screen, the colour of which signified the item to select in pressure menu

Navigate to the corresponding colour in the pressure menu (NDH) while tapping the crosshair (DH)

Tested

- Menu size, target distance

Measures

- Time
- Non-Dominant Hand (NDH) accuracy
- Dominant Hand (DH) accuracy

Pressure
Menu

Crosshair
Target

Results

Menu Size	Selection Time (ms)	Pressure Accuracy	DH Error Distance (px)
Control (0 items)	649.85	n/a	21.8
5 Items (W= 2N)	2334	93.6%	27.5
7 Items (W= 1.4N)	2520.2	96.1%	18.8
10 Items (W = 1N)	2889.5	89.3%	25.3

Pressure very successful – accuracy for both hands was high as time increased

Maintaining

Navigate to a particular level of pressure and maintain that level as accurately as possible while selecting DH targets

Tested

- Target pressure (2,4,6,8N)
- Maintain time (5,10,1,20s)

Measures

- Pressure variance
- Pressure error

Results

Target Pressure	Mean Pressure Variance (N)	Mean Pressure Error (N)
2N	0.648	0.157
4N	0.349	0.162
6N	0.292	0.135
8N	0.104	0.096

People very good at maintaining pressure while selecting

Overall results

Low impact on dominant hand accuracy

Pressure accuracy high across all conditions

Accurately select targets by both applying and releasing pressure

Maintain pressure more accurately as the target pressure increases

✓ Non-dominant hand pressure works very well

FineTuner

THERMAL FEEDBACK

Thermal interaction

Temperature an unused part of touch feedback

- It is always present
- Humans are very sensitive to temperature

Can we use it for communication?

- Very strong emotional response to temperature
- Key technique for determining material properties
- Children's hotter/colder game

Alternative to a vibration motor?

Thermal feedback

Vibration motors don’t give a convincing feeling of any material

- Their ability to produce stimuli is much less than human perception capabilities
- Engineering challenges make this difficult to fix

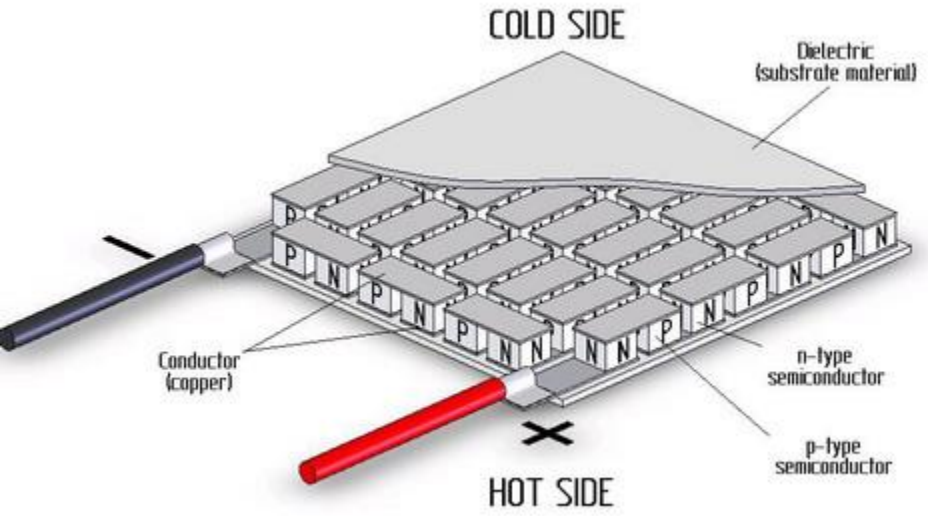
Thermal devices stimulate the skin in a convincing way

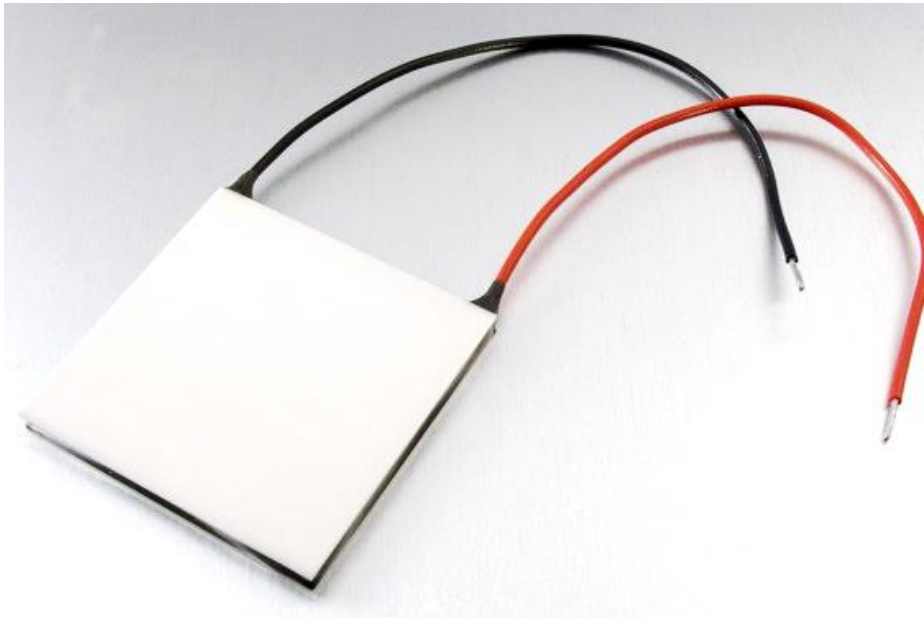
- Same as occurs when touching warm or cool objects
- Feeling is therefore much more realistic

Temperature hardware

Peltier heat pumps

- Elements that can be heated or cooled rapidly
- Standard components, low cost





Thermal feedback device

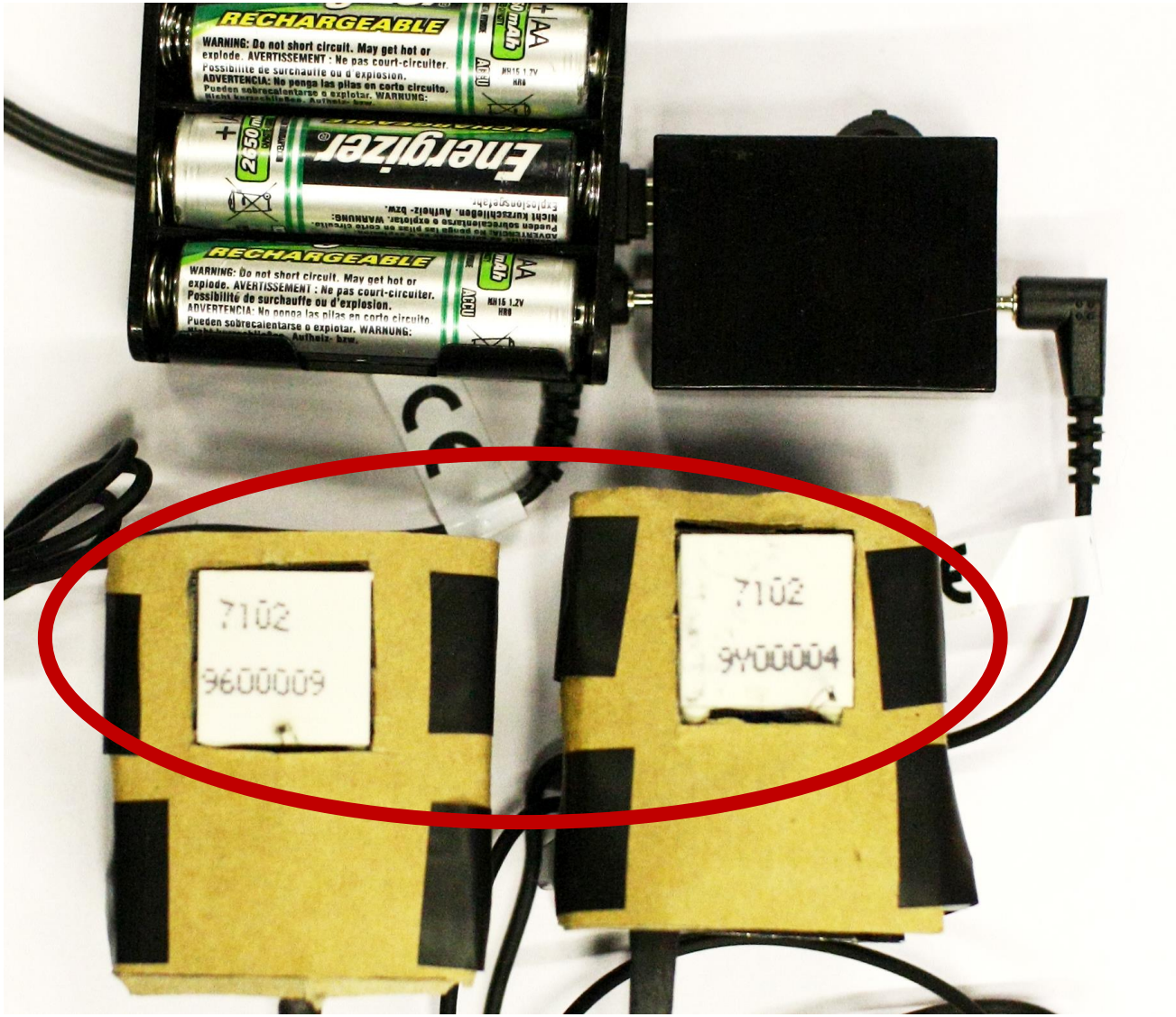
We built a thermal feedback device

Has 2-4 Peltier elements

Battery powered

Communicates via Bluetooth

Power consumption similar to video playback for our thermal cues


RECHARGEABLE
WARNING: Do not short circuit. May get hot or explode. AVERTISSEMENT : Ne pas court-circuiter.
Possibilité de surchauffe ou d'explosion.
ADVERTENCIA: No ponga las pilas en corto circuito.
Pueden sobrecalentarse o explotar. WARNUNG:
Energizer
RECHARGEABLE
WARNING: Do not short circuit. May get hot or explode. AVERTISSEMENT : Ne pas court-circuiter.
Possibilité de surchauffe ou d'explosion.
7102
9600009
7102
9400004

Studies

Investigated perception of thermal stimuli in many different ways

- Body location
- Amount of change required
- Rate of change
- Static vs mobile use
- Through clothes vs bare skin
- In varying indoor and outdoor environments

Indoor mobile thermal study

Effects of changing environment

Front of School

Back of School

Design Recommendations

Palm is most sensitive but wrist and arm are acceptable

Stimulus intensities should be at least 3°C to guarantee detection but 6°C at most for cooling and <6°C for warming to ensure comfort

Both warm and cool stimuli are detectable and comfortable but cool stimuli are preferred

- Cool detected fastest

Moderate rate of change (2-3°C/sec) provide good saliency but lower rate of change required for high intensity stimuli

Users' affective response very strong

Applications

Thermal icons

Notifications and warnings

- Multimodal combination with vibrotactile to increase range of non-visual display options

Enhancing emotional experiences

- Thermal feedback can enhance the experience of consuming media (images, music)

Conclusions

Haptic interaction can be problematic as devices don't match the capabilities of the human

- Creates experiences that do no feel 'real' or engaging

Need to design better haptic interactions

- Use aspects of touch for which we have good devices

Pressure input

- Rich form of control
- Users can control it well with both hands
- Hardware simple to add to mobile devices, other products

Conclusions

Thermal feedback

- Rich part of human touch experience
- Creates a more emotional link
- Don’t need large changes in temperature to elicit responses

New ways to design haptic interactions

- If we create new interactions like this then user experiences will be much richer and more engaging than what is available now

New ways to design haptic interactions

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