TACTILE ACTUATOR TECHNOLOGIES
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Eccentric rotating mass (ERM)

- Vibration created by rotating off-centric mass with a motor.
- Common actuator. Used in toys, game controls, mobile phones...
- Frequency 90-200Hz.
- Power drain 130-160 mA.

- Good
  - Cheap.
  - Strong vibra – good for alerts.
  - No huge requirements for electronics.
- Downsides
  - Slow (30-50ms) while acceleration takes time.
  - Not suitable for high quality feedback.
  - Actuator can be sizable.

ERM actuators. Source: Precision microdrives
Eccentric rotating mass (ERM)
Linear resonant actuator (LRA)

- Magnet moved forward-backwards w/ coil.
- Common actuator in mobile phones.
- Frequency 150-200Hz, single frequency.
- Power drain 65 - 70 mA.
- Some have autotune which enables LRA to lock on resonant frequency.
- Can be multifunction device (MFD) with loudspeaker.

- Good
  - Cheap.
  - MDF makes possible to sync audio and tactile feedback.
- Downsides
  - Faster than ERM, but still rather slow (20-30ms).
  - Medium strength vibra -> alerts?
  - Braking the actuator can be complicated.
Linear resonant actuator (LRA)
Piezo

- Current bends the ceramic actuator.
- Variety applications e.g. motors, loudspeakers, sensors....
- High-end solution.
- Frequency 150-300Hz.
- Power drain 300mA.

- Good
  - Fast < 5ms.
  - High fidelity feedback.
  - Different mounting options e.g. the whole display can move.

- Downsides
  - Required electronics is more complex.
  - Cost?

Piezo

Bending piezo actuators. Source: Piezo Systems inc.
Electro-active polymers

- Group of polymers that change shape/size when current is applied.
- High-end solution.
- Typically attached to mass e.g. device battery.

- Good
  - Fast, < 5ms.
  - High fidelity feedback.
  - High strain.
  - Opens new innovation possibilities?

- Downsides
  - Electronics, need to generate voltages greater than 300v.

EAP examples - Robotics

Summary actuators

<table>
<thead>
<tr>
<th>Actuator Types and Characteristics</th>
<th>ERM</th>
<th>LRA</th>
<th>Piezo Module</th>
<th>EAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form Factor</td>
<td>Bar or hockey puck</td>
<td>Hockey puck</td>
<td>Matchstick</td>
<td>Flat panel</td>
</tr>
<tr>
<td>Approximate Size</td>
<td>11 x 4.5 dia. mm</td>
<td>10 x 3.6 mm</td>
<td>3.5 x 3.5 x 42 mm</td>
<td>45 x 38 x 0.8 mm</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>130-160 mA RMS @3V</td>
<td>65-70 mA RMS @3V</td>
<td>300 mA RMS @3V</td>
<td>Ask vendor</td>
</tr>
<tr>
<td>Frequency Range</td>
<td>90-200 Hz (non-uniform strength)</td>
<td>150-200 Hz, single frequency (e.g. 175 Hz)</td>
<td>150 to 300 Hz usable</td>
<td>90 to 125 Hz (resonant peak), 50-200 Hz usable</td>
</tr>
<tr>
<td>Mechanical Time Constant</td>
<td>50 ms</td>
<td>30 ms</td>
<td>&lt;5 ms</td>
<td>&lt;5 ms</td>
</tr>
<tr>
<td>Durability</td>
<td>Variable</td>
<td>Very durable</td>
<td>Very durable</td>
<td>Excellent</td>
</tr>
<tr>
<td>Fidelity of Sensations</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

- Measurements with N8 indicate that haptic feedback doubles the single event (opening/closing menu) power consumption.
- In practice, when haptic feedback is applied, the power consumption is 0.95 – 7% more than without haptic feedback [http://www.immersion.com/docs/haptics-power-consumption-analysis.pdf].
Tactus

- Flat touchscreen surface can changed to have physical buttons.
- Buttons raised fully within 1s

Discussion: while system is essentially a hardware component, the UI layer needs to be synched early in design phase?

Senseg

• Creates Coulomb force based pressure sensations between finger and touch screen surface by passing current to insulated electrode.

• Marketing claims: High fidelity, different textures.

• How much voltage is required?

http://senseg.com/technology/senseg-technology
THANK YOU