Tactile Arrays for Virtual Textures

Submitted by Alan Christopher Brady, to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Physics, September 2010.

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(Signature) ........................................................................................................
Abstract

This thesis describes the development of three new tactile stimulators for active touch, i.e. devices to deliver virtual touch stimuli to the fingertip in response to exploratory movements by the user. All three stimulators are designed to provide spatiotemporal patterns of mechanical input to the skin via an array of contactors, each under individual computer control. Drive mechanisms are based on piezoelectric bimorphs in a cantilever geometry.

The first of these is a 25-contactor array (5 × 5 contactors at 2 mm spacing). It is a rugged design with a compact drive system and is capable of producing strong stimuli when running from low voltage supplies. Combined with a PC mouse, it can be used for active exploration tasks. Pilot studies were performed which demonstrated that subjects could successfully use the device for discrimination of line orientation, simple shape identification and line following tasks.

A 24-contactor stimulator (6 × 4 contactors at 2 mm spacing) with improved bandwidth was then developed. This features control electronics designed to transmit arbitrary waveforms to each channel (generated on-the-fly, in real time) and software for rapid development of experiments. It is built around a graphics tablet, giving high precision position capability over a large 2D workspace. Experiments using two-component stimuli (components at 40 Hz and 320 Hz) indicate that spectral balance within active stimuli is discriminable independent of overall intensity, and that the spatial variation (texture) within the target is easier to detect at 320 Hz that at 40 Hz.

The third system developed (again 6 × 4 contactors at 2 mm spacing) was a
lightweight modular stimulator developed for fingertip and thumb grasping tasks; furthermore it was integrated with force-feedback on each digit and a complex graphical display, forming a multi-modal Virtual Reality device for the display of virtual textiles. It is capable of broadband stimulation with real-time generated outputs derived from a physical model of the fabric surface. In an evaluation study, virtual textiles generated from physical measurements of real textiles were ranked in categories reflecting key mechanical and textural properties. The results were compared with a similar study performed on the real fabrics from which the virtual textiles had been derived. There was good agreement between the ratings of the virtual textiles and the real textiles, indicating that the virtual textiles are a good representation of the real textiles and that the system is delivering appropriate cues to the user.
## Contents

1 Introduction 23

2 A review of the literature 27
   2.1 The sense of touch ........................................ 27
      2.1.1 Communication through touch ....................... 28
   2.2 The Physiology of the Sense of Touch .................... 31
      2.2.1 The structure of skin & its touch receptors .......... 32
      2.2.2 Neurophysiology ....................................... 35
      2.2.3 Psychophysics of touch perception .................... 39
   2.3 Tactile Displays - state of the art ....................... 45
      2.3.1 Approaches for distributed displays ................. 45
      2.3.2 The Optacon .......................................... 48
      2.3.3 StroSS ............................................. 51
   2.4 The Exeter Tactile Array .................................. 54
   2.5 Summary .................................................. 56

3 Design Considerations for Tactile Arrays 57
   3.1 Stimulation method ........................................ 57
   3.2 Contactor spacing ........................................ 58
      3.2.1 Experimental study - Pin spacing ..................... 59
   3.3 Choice of Actuator Technology ............................ 61
      3.3.1 Piezoelectric bimorphs ................................. 61
   3.4 Choice of Bimorph ........................................ 63
3.4.1 Design Parameters ........................................ 63
3.5 Modelling ....................................................... 64
  3.5.1 Some useful relations[1] .................................. 64
  3.5.2 Simple Dynamic Model of a Bimorph .................. 65
  3.5.3 An improved model ...................................... 67
3.6 Other design considerations .................................... 70
  3.6.1 MRI compatibility ........................................ 70
  3.6.2 Complexity and form ..................................... 72
3.7 Summary .......................................................... 72

4 A 25 Contactor Array for Active Exploration .................. 73
  4.1 Design ......................................................... 73
  4.2 Hardware Implementation .................................... 75
    4.2.1 Performance ............................................. 77
  4.3 A simple controller .......................................... 78
  4.4 A Tactile Mouse .............................................. 83
    4.4.1 Software .................................................. 84
  4.5 Experiments with active virtual touch ..................... 85
    4.5.1 Orientation of lines .................................... 86
    4.5.2 Shape identification .................................... 89
    4.5.3 Line following ........................................... 91
  4.6 Discussion .................................................... 93

5 Real-time Representation of Texture ............................ 95
  5.1 Introduction ................................................ 95
  5.2 An improved tactile array .................................. 96
  5.3 Actuators .................................................... 96
    5.3.1 Construction ............................................. 97
  5.4 Position input ............................................... 100
  5.5 Drive Electronics .......................................... 101
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5.1</td>
<td>Data transfer</td>
<td>102</td>
</tr>
<tr>
<td>5.5.2</td>
<td>Interface</td>
<td>104</td>
</tr>
<tr>
<td>5.5.3</td>
<td>Digital to Analogue Conversion</td>
<td>105</td>
</tr>
<tr>
<td>5.5.4</td>
<td>Drive Amplifiers</td>
<td>107</td>
</tr>
<tr>
<td>5.6</td>
<td>Computer control</td>
<td>109</td>
</tr>
<tr>
<td>5.6.1</td>
<td>PC hardware</td>
<td>109</td>
</tr>
<tr>
<td>5.6.2</td>
<td>Evolution of the Software</td>
<td>110</td>
</tr>
<tr>
<td>5.6.3</td>
<td>Software design</td>
<td>111</td>
</tr>
<tr>
<td>5.7</td>
<td>Timing issues</td>
<td>116</td>
</tr>
<tr>
<td>5.8</td>
<td>Virtual Texture Experiments</td>
<td>118</td>
</tr>
<tr>
<td>5.8.1</td>
<td>Texture pilot study</td>
<td>119</td>
</tr>
<tr>
<td>5.9</td>
<td>Formal experiments examining the tactile perception of texture</td>
<td>122</td>
</tr>
<tr>
<td>5.9.1</td>
<td>General comments</td>
<td>122</td>
</tr>
<tr>
<td>5.9.2</td>
<td>Random variation as “Texture”</td>
<td>122</td>
</tr>
<tr>
<td>5.9.3</td>
<td>Discrimination of Vibrotactile Intensity</td>
<td>123</td>
</tr>
<tr>
<td>5.10</td>
<td>Experimental investigation of a perceptual space for virtual texture</td>
<td>125</td>
</tr>
<tr>
<td>5.10.1</td>
<td>The revised experiment</td>
<td>128</td>
</tr>
<tr>
<td>5.10.2</td>
<td>A subsidiary experiment</td>
<td>135</td>
</tr>
<tr>
<td>5.11</td>
<td>Conclusion</td>
<td>136</td>
</tr>
</tbody>
</table>

6 Virtual Textiles

6.1 The HAPTEX project | 140
  6.1.1 Project partners | 141
  6.1.2 Overview of the system | 142

6.2 Modelling the Fabric | 143

6.3 HAPTEX System Hardware | 144
  6.3.1 Force feedback elements | 144

6.4 The HAPTEX Tactile Display | 148
  6.4.1 Control system | 148
  6.4.2 The HAPTEX Tactile Array | 154
6.5 Performance of the HAPTEX System ........................................ 167
6.5.1 Subjective performance .................................................... 167
6.5.2 An Experiment with Virtual Textiles: Comparing real fabric
with virtual fabric ............................................................... 172
6.6 Summary ............................................................................ 176

7 Conclusions ........................................................................... 183
7.1 Tactile displays ..................................................................... 183
7.2 Vibrotactile stimulation ......................................................... 184
7.3 Future work ......................................................................... 185
7.4 Final remarks ....................................................................... 187

A Publications and conference presentations ......................... 189

B The ROSANA Project ............................................................... 191
B.1 Stimulator hardware .............................................................. 193
B.2 Control system .................................................................... 197
B.3 Results .............................................................................. 198

C Measurement of frequency response .................................... 201
C.1 Accelerometer ..................................................................... 202
C.2 Example Results ................................................................ 203

D Subjective experience of vibrotactile stimuli across the frequency
spectrum .................................................................................. 207

E Other Experiments ................................................................ 209

F Details of software ................................................................ 211
F.1 Input files ........................................................................... 211

G Amplitude scales .................................................................. 217

H An example texture of a texture file .................................... 223
I  Details of the Kawabata Evaluation System  225

J  Initial evaluation of the renderer  231
   J.1  The HAPTEX Tactile Renderer  . . . . . . . . . . . . . . . . . . . .  231
   J.2  Evaluation of the renderer  . . . . . . . . . . . . . . . . . . . . .  233