Reusable adhesives enable bipolar force output to the human fingerpad

dr. Staas de Jong
Leiden University
apajong@xs4all.nl

1. CONTEXT

This poster presents work in progress on the fingertip force transducer of the Ghostfinger system. Ghostfinger is a new multimodal technology for highly dynamic up/down fingertip haptics and control. Its purpose, user interface, and programming interface have been introduced in [1]. One crucial component of the overall hardware is the *keystone*, a rigid force transducer that is kept pressed against the user's fingertip during use. This transducer provides both the positional input and force output that enable the haptic conditions for control actions to be computationally determined in real time. Here, we discuss an innovation whereby the keystone becomes a transducer capable of bipolar force output to the human fingerpad.

2. REUSABLE ADHESIVES ENABLE FINGERPAD BIPOLAR FORCE OUTPUT

In the existing situation, the keystone is kept in contact with the user's fingerpad due to its attachment to an adjustable strap that is placed around the fingertip. This means that upward forces are applied mainly at the fingerpad, while downward forces are applied mainly along the dorsal side of the fingertip (see Figure 1).

The idea for potential improvement was then one of adding some type of adhesive top layer to the keystone fingerpad contact area: This layer should bond to palmar fingertip skin, so that at the fingerpad, downward forces would be applied, too. Additionally, for realistic use, this adhesive top layer should then be reusable over many cycles of attachment, de-attachment, and storage.

A wide range of adhesive materials was considered and acquired for this purpose, and preliminary testing focused on to-fingerpad adhesion duration under a fixed downward force level, measured both initially and for repeated re-use (see Figure 2).

Based on the results, a number of new keystone prototypes were constructed, one of which is shown in Figure 3. The prototypes were then tested and ranked based in part on their performance during repeated 60-second test runs, each consisting of attachment, steady -2.0 N force output, +1.0 / -1.0 N block pulsed force output at 10 Hz, and de-attachment. The contents of these test runs are demonstrated, in shortened form, in the video provided in the Appendix.

3. ADDITIONAL ADVANTAGES

Besides enabling bipolar force output at the human fingerpad, the new design also has other advantages:

- *Anatomical specificity:* The anatomical target location of force output has become limited to the fingerpad specifically (see Figure 3). This is the location on the finger where also during everyday up/down fingertip actions, forces typically are applied to become perceived.
- *Ease of use:* The strapless design enables users to attach and de-attach the transducer with less instruction and in a shorter time (see Appendix).
- *Comfort:* The adhesive layer now attaches the keystone to the fingertip exclusively via the fingerpad. This eliminates discomfort related to pressures and temperatures applied by the strap over prolonged use.

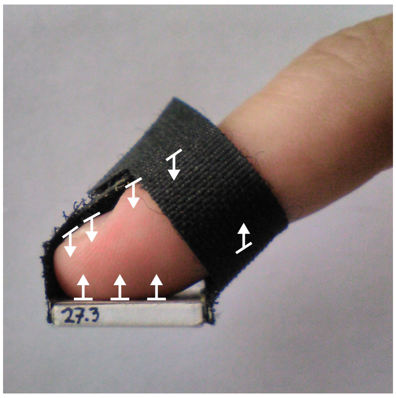

Figure 1. The existing, strapped keystone design. The bars with arrows indicate anatomical locations where output forces are applied. For upward forces, this is mainly at the fingerpad. For downward forces, this is mainly along the dorsal side of the fingertip.

Figure 2. Photograph taken during preliminary testing of candidate adhesive materials. Here, measuring to-fingerpad adhesion duration under a -400 g vertical force.

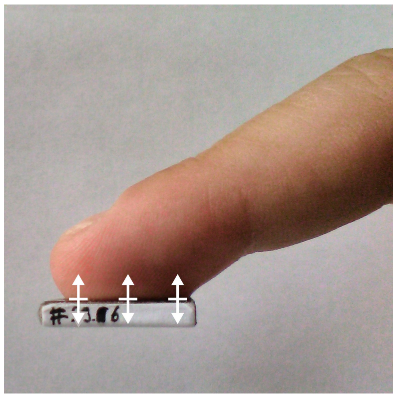

Figure 3. The new, strapless keystone design. Both upward *and* downward forces are now applied at the fingerpad.

4. NEXT STEPS

As candidate materials for the adhesive layer continue to be evaluated, some factors expected to be involved in key trade-offs are:

- the stiffness and spatial uniformity of adhesion maintained during usage sessions;
- the amount of wear of the adhesive layer over many usage sessions;
- the thickness of the adhesive layer;
- the amount of mechanical damping by the adhesive layer (minimized for maximized temporal precision of perceived force output);
- the use of medical-grade hypoallergenic adhesives.

5. REFERENCES

[1] De Jong S, 2017 Ghostfinger: a novel platform for fully computational fingertip controllers. In *Proceedings of the 2017 international conference on New Interfaces for Musical Expression* (NIME17) 387-392.

6. APPENDIX

A video demonstrating attachment/de-attachment and applied force output is at *https://youtu.be/_UZNuSozLEE* .