Force Desk

A Platform for Live Laptop Performance

Jeremy Rubin
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA, USA
jr@mit.edu

ABSTRACT

Amid a growing number of thoroughly un-engaging electronic music performances, this works presents a novel electronic music device,*Force Desk*, which is designed to assist musicians who do live performances with laptop devices. Using the Force Desk is a highly haptic experience. Furthermore, the haptic response level is easily customized. As such the Force Desk is potentially suited to the development of a new style of virtuosic laptop based performances.

Author Keywords

DJ, Live Performance, Electronic Music

ACM Classification

H.5.5 [Information Interfaces and Presentation] Sound and Music Computing, H.5.2 [Information Interfaces and Presentation] User Interfaces—Haptic I/O H.5.2 [Information Interfaces and Presentation] User Interfaces—Input devices and strategies.

1. INTRODUCTION

Watching a musician perform with a laptop can be thoroughly boring. Whereas a traditional musician delivering vocals or playing a piano, guitar, or drums gives strong physical stage presence to an audience, a performer using a laptop is more disengaged with the audience as it is not easily possible to correlate their actions with the sounds that they create.

Furthermore, the performer themselves may have difficulty connecting their physical movement and passion to the music if it is through a physically un-engaging device such as a mouse or a QWERTY keyboard.

Additionally, a laptop has poor *action parallelism*, in that it is difficult for a user to control multiple parameters at once. For instance, a text entry field would preclude any further use of the mouse or keyboard except for that purpose. Generally, this means that all user input actions on a laptop must occur somewhat serially (it's possible to map otherwise, but generally typing consumes the full bandwidth of a user's output, and there is a large amount of muscle memory in this mode of laptop operation that might be difficult to untrain). These methods of input are also highly discretized and without continuous haptic feedback, hard for a performer to get an intuitive feel for how their actions will map.

The Force Desk is an attempt to address the above concerns. The Force Desk provides a Laptop user 4 new degrees of freedom that are easily concurrently accessed with the keyboard and mouse, can convey a physical connectedness to the music for both the musician and audience, offers continuous input with provide fine grained haptic feedback for musicians to control their actions more precisely.

2. DESIGN

The core design of the force desk is a platform which allows the user to move their laptops in a two dimensional xy plane, provide force along z axis, and spin about the z axis (4 total degrees of freedom $xyz\omega$). The platform provides mechanical haptic feedback via springs, as the platform moves toward extreme positions, more force is received back by the user. Upon releasing the device, the spring force will cause it to return to center, hence delivering a very dynamic and engaging experience. Furthermore, the limits on the xy motion are a circle, which allows for smooth contiguous movement when the device is pushed to the max. Sensors will pick up the amount of force exerted and the physical displacement.

Figure 1 shows the CAD design of the Force Box being assembled. The models were created using the parametric CAD tool FreeCAD. An earlier design of the Force Box used transfer bearings[1], but the design was reworked after being unable to find sufficiently smooth rolling bearings.

3. CONSTRUCTION

3.1 Mechanical

The device was constructed via laser cut acrylic. Acrylic was selected over other materials as it provides a smooth surface for the rims to slide over the middle retainer. In future revisions, CNC Mill or waterjet would be preferable as the lasercutter had slight warping on various features of the design. This required some post-cut cleanup with a power drill for screw holes.

When it came to physically constructing the design from Figure 1, there were a couple additional considerations that complicated or necessitated design changes.

3.1.1 Bottom Case

In the initial design, as shown in Figure 1, the bottom case was not appropriate for a few reasons.

Maitnence.

In order to change or tune the Force Box, it is necessary to swap out or add more springs. Having a closed design makes

[1]small unidirectional ball bearings that can be mounted by screwdriver

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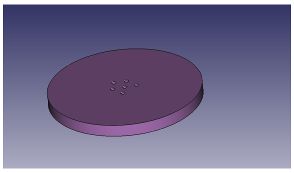
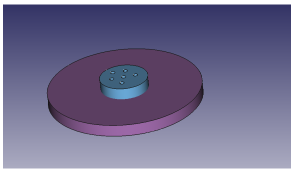
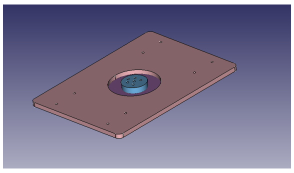


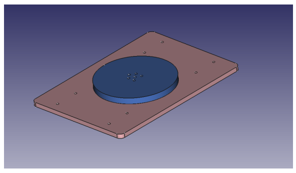
(a) Bottom Rim



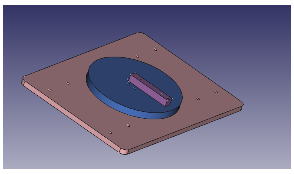
(b) Inner Shaft



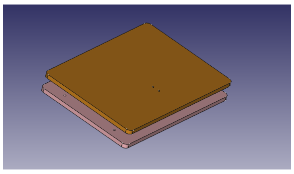
(c) Middle Retainer



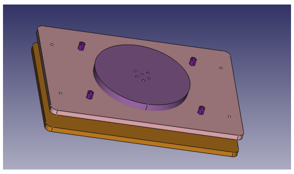
(d) Top Rim. This assembly can move in a circle with radius $r_{retainer} - r_{shaft}$, constrained to xy



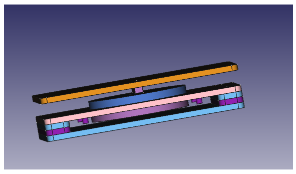
(e) Load Beam for pressure sensitivity



(f) The top pad supports the laptop.



(g) Standoffs to support the springs once they are mounted



(h) Bottom case assembly

Figure 1: The CAD assembly of the Force Desk

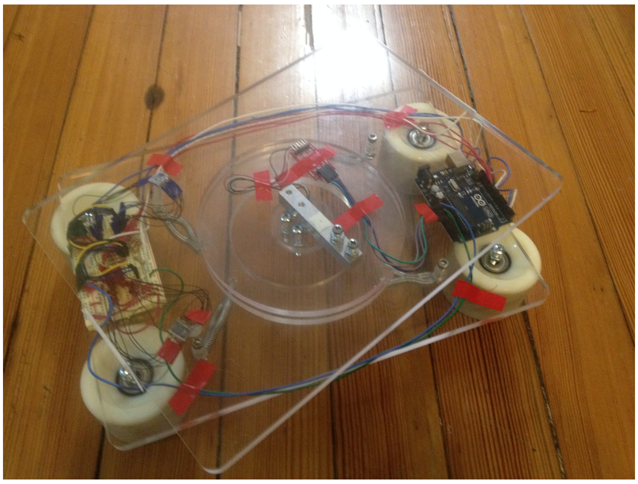


Figure 2: The Completed Device

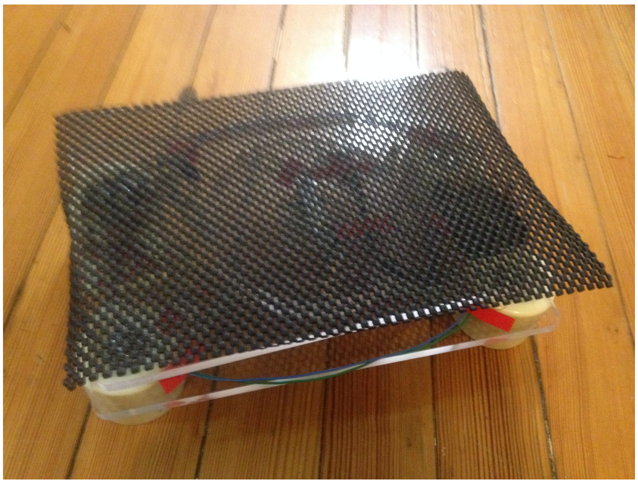


Figure 3: Kitchen Mat grip material

this difficult to do. Furthermore, springs should always be disconnected after use, as they will wear if left stretched for long periods of time, and the tension on the entire device is likely bad for its longevity.

Grip.

Having a flat piece of acrylic was not going to provide the grip needed to keep this device on a table with a user providing significant force.

Thus the design was modified to use Urethane longboard wheels, as shown in Figure 4. These are an almost ideal material for this purpose as skateboard wheels are designed to be highly grippy. Additionally, as they are countersunk, there is no issue with the bolts hitting the table. Last, but not least, the author is an avid longboarder and had an extra set of wheels available.

3.1.2 Top Pad

In the initial design, there were a couple problems with the design of the top, in a similar vein to the problems with the bottom.

Grip.

The initial plan was to use velcro to keep a laptop mounted. However, this was unsatisfactory because it required velcroing any laptop to be used on the device.

Not Countersunk.

It would be difficult to countersink screws in acrylic, and might also harm the structural integrity of the device. This also affected the plan to user velcro, as they protruded too much.

The solution was to use grippy cut of kitchen mat over the top platform, as shown in Figure 3, velcroed to the sides. This provided a high grip surface for any laptop to be put down, and had enough padding to negate the countersunk concern.

3.2 Electrical/Sensor

For the sensors, and Arduino Uno was used as a embedded controller. A 10 Kilogram load beam was used as the sensor, with a HX711C 24-bit load cell amplifier. Two Avago ADNS-3530 optical mouse sensors were used to gauge the $xy\omega$ displacement. The mouse sensors were sampled and aggregated using hardware interrupts, and the load cell was polled in a loop. The Arduino sampled the sensors at

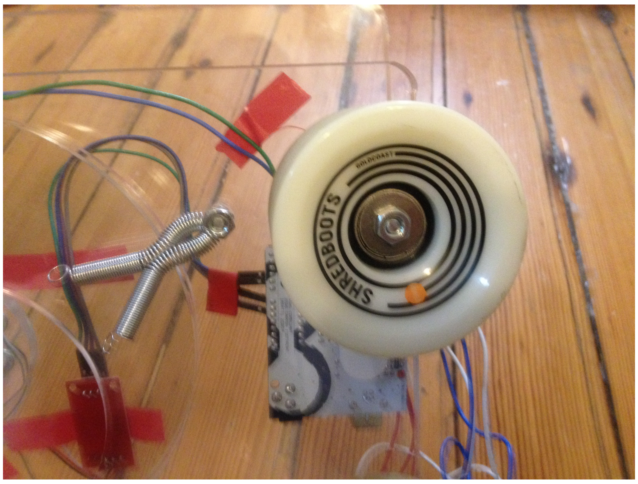


Figure 4: Urethane longboard wheels serving as the base

roughly 60hz – it could have sampled more quickly, but the mouse sensors were noisy unless aggregated for some period. A more advanced software filtering algorithm could be used as well.

4. MUSICAL MAPPING

The mapping of the device was performed in PureData. Unfortunately, due to time constraints and misbehaving mouse sensors, the author did not finish a complete mapping of the device. In experimentation with the mapping, the author was able to make a very compelling demo using pressure to change the pitch of a key controlled oscillator. Generally, it seems that the device has a lot of potential for amazing mappings. Each of $xyz\omega$ can be read with not only position/amount, but also with velocity and acceleration due to the high sample rate. With all of the degrees, it is important to provide a taring and calibrating routine to combat drift if and when it occurs[2].

4.1 Mapping x

The x axis (side to side) is ideal for shorter motions, such as a vibrato pitch bend. From personal experience, it is difficult to sustain a lateral force, hence the suggestion that these actions should be shorter lived.

4.2 Mapping y

The y axis (front to back) is great for both longer and shorter motions, which makes it slightly more versatile than x. Therefore y can be used for fader type operations, or even percussive elements as it is easier to do a "rowing" motion.

4.3 Mapping ω

The mapping of ω can be decoupled from that of xy completely. With large displacements on ω, it can be difficult to appropriately use a keyboard. Therefore, this is ideal for disruptive effects, such as scratching, rewinding a sample, or switching contexts/songs.

4.4 Mapping z

The z axis is perhaps the most difficult to map. This is because it is difficult not to apply pressure when making $xy\omega$ motions. Therefore, when mapping z it may be desirable to have it deactivate when an $xy\omega$ motion is occurring and pressure is within a bound. Pressure offers a very intuitive feel, as fingertips are extremely pressure sensitive. With 24 bits of resolution, the output is also fine grained enough to allow for precise control. Another interesting use for z is as a control axis – pressing down harder can be done with the wrists, and can switch contexts smoothly, perhaps surfacing different instrument controllers at each depth. A high pass filter on z could also be used to eek out percussive taps, allowing it to become a drum trigger as well. Interestingly, z can differentiate a push versus a pull. As upwards pressure is a very explicit signal, this can be used to perform rare effects, somewhat the equivalent of wailing on a whammy bar.

[2]Calibration can even be used creatively like a Capo

5. FUTURE WORK

There are several exciting directions I'd like to take the Force Desk.

5.1 Standalone Device

It seems that the Force Desk has potential to be more than just an accomplice to laptop music, but has creative potential in it's own right. The spring loaded table format is really natural feeling, and the pressure sensitive table allows for percussive elements. To increase the Force Desk's Standalone credibility, there are a couple things that could be explored:

5.1.1 Capacitive Touch Sensing

By making the panel sensitive to capacitive touch, with some grid layout, it could be used as a very capable control surface for input. It would be amazing to mount an RGB LED per pad to illuminate it with information such as pressure applied or current configuration.

5.1.2 4-Axis Pressure

By increasing the number of load beams to one per corner, it might be possible to localize the pressure. When observing users playing the Force Desk, I noticed they would often press on different corners of the laptop. Having pressure localized would enable these to have different effects.

5.2 Further Exploration of Mappings

Admittedly, my mappings were underdeveloped. Partly this is a fault of my musical inexperience. I'd love to develop several applications which showcase some of the ideas for mappings presented in section 4. Ideally, I'd look into collaborating with someone with more musical maturity to be able to make the mappings higher quality.

5.3 Performance

The Force Desk can be used to make some really wild sounds. With practice, I think it could make for a very interesting performance. To test this, I will try to take it to a music improv night I sometimes attend to experiment – of course, this has the drawback that it would not be solo, but I think would be optimal for exercising with the device to build virtuosic prowess.

5.4 Production

This design is relatively simple, but I think that it is a lot of fun. I think it would be highly rewarding to, after developing more mappings make a "reproducible build", and to sell a kit or make plans available online if there is interest.

6. ACKNOWLEDGMENTS

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