Towards a 3d-printed Compliant Attachment for Guitar Straps

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***Abstract*—In this short paper I describe an ongoing design project for a guitar strap-based stretch-sensor attachment for expression control with electric guitar effects pedals. To contextualise the project, I address similar works employing 'non-rigid' interaction techniques using electronic textiles and other flexible materials. Lastly, I propose that non-compliant mechanisms can be a more reliable, robust, scalable and sustainable alternative for the next iteration of the design.**

I. Introduction

Most commercial digital musical instruments (DMIs) often rely on similar input mechanisms such as linear potentiometers (e.g., faders and knobs), buttons, switches and rotary encoders, to the extent that such interaction elements are even prevalent in the skeuomorphic graphical user interfaces of digital audio workstations and virtual studio technologies. The few exceptions to these input modalities in DMIs are generally considered divergent designs. Examples include the ROLI Seaboard, which is a keyboard-type instrument that uses a continuous sensor covered with flexible rubber instead of keys, or the Theremin, which is played without physical contact by using antennas which capacitively sense the mid-air hand gestures of its player. However, in non-commercial spheres, new instruments are being created every year as research and tinkering projects that explore a diverse range of interaction techniques, sensors, and materials [6]. A recent stream of exploration are non-rigid musical interfaces (NRMI), which seek to employ deformable, flexible and shapeshifting input modalities [4]. In this paper, I present my work in this space, consisting of a strap-based e-textile stretch sensor used as an expression controller for the electric guitar, as well as the conceptualisation and design process for making it, its current iteration, and my speculations for using compliant mechanisms for the next version of the device and how these can be applied to other musical interactions.

II. Background

In a recent survey study by Boem et al. [4], address how non-rigid interfaces have been extensively investigated in the context of human-computer interaction but have been seldom explored as inputs for musical instruments. Moreover, through their survey they identified that NRMIs often employed malleable and deformable materials such as rubber and fabric to provide performers with the ability to make music by stretching, bending and twisting their instrument's inputs (ibid). Similarly, while e-textiles are increasingly being researched for the development of wearables [12, 16, 17] and electronic devices [14], they are rarely employed as non-rigid interaction modalities for DMIs. Leveraging on the wearable and flexible qualities of e-textiles I designed an augmented guitar strap to be used as an expression controller for effects pedals [3]. The concept behind this stretchy strap emerged from a somaesthetic design process [8], in which I explored ways of supporting guitar practice with media by focusing on the interrelationship between the instrument and the body [2]. The concept was demonstrated through a low fidelity prototyped (Figure 1), and was subsequently refined at an "absurd musical instruments" hackathon [11], where I employed e-textiles and a Bela board [13] to make a functional prototype (Figure 1). After receiving funds from stipends and grants, I collaborated with an e-textiles company and London-based Augmented Instruments Ltd. (AIL) to make further iterations of my design, which culminated in a guitar strap attachment (Figure 1) to be used in conjunction with a functional expression guitar pedal and a multi-effects floorboard (Line 6 Helix LT)[1].

Figure 1. Stretchy Strap Iterations.

[1] Concept video of the Stretchy Strap.

In comparison to other technologies that could have been employed such as motion capture or accelerometers [5, 7, 15], the stretchy strap we designed with AIL provides tactility and force feedback from the stretch fabric used for the sensor, which is an interaction modality for guitars akin to the string bender, an alteration for guitars generally used in Country music. However, while the stretchy strap device can be used expressively, the e-textile sensor proved to be prone to faults over time, associated with the textile's fragility and hysteresis.

III. Design speculations

Among the alternatives that I have considered to tackle the issues that emerge from textile-based sensors are silicone and conductive fabric composite sensors [1], as well as mechanical solutions utilising springs or compliant mechanisms [9, 10]. However, in terms of production requirements, robustness, maintenance and scalability, the compliant mechanism route appears to be the most appropriate one, as manufacturing the aforementioned composite sensors [1] involves specialised laboratory equipment and multiple fabrication steps up to the point where a scalable composite substrate can be mass-manufactured using a laser cutter. In contrast, a compliant mechanisms approach could allow for print-in-place, composite prints (with conductive and non-conductive layers) and/or single part designs. Moreover, properties of compliant mechanisms such as bi-stability and binary stiffness [9, 10] which could be explored to tackle one of the most critical challenges of a strap-based sensor attachment for the guitar which is to compensate for the weight of the guitar. Furthermore, as with other novel interaction techniques, these mechanisms can also be further explored in digital musical instrument applications.

IV. Responsible innovation

My work contributes to positive impact in society through the exploration and design of artefacts for artistic expression (specifically, music). Moreover, additive manufacturing and 3d-printed compliant mechanisms are sustainable fabrication techniques, and the substrates required to build prototypes using these methods can be reused.

V. Author bio

Dr. Juan Martinez Avila is an Assistant Professor in Computer Science at the University of Nottingham. As part of the Mixed Reality Lab, he steers an interest group that investigates intelligent and interactive music technology research through practice-based methods, ethnography, participatory design, and embodied design ideation.

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