# Pitch Fork
# A Novel tactile Digital Musical Instrument


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## ABSTRACT

Pitch Fork is a prototype of an alternate, actuated digital musical instrument (DMI). It uses 5 infra-red and 4 piezo-electric sensors to control an additive synthesis engine. Iron bars are used as the physical point of contact in interaction with the aim of using this materials natural acoustic properties as a control signal for aspects of the digitally produced sound. This choice of material was also chosen to affect player experience. Sensor readings are relayed to a Macbook via an Arduino Mega. Mappings and audio output signal is carried out with Pure Data Extended.



## Author Keywords

NIME, DMI, Material Computation, Pitch Fork

## ACM Classification

- **Applied computing∼Sound and music computing**


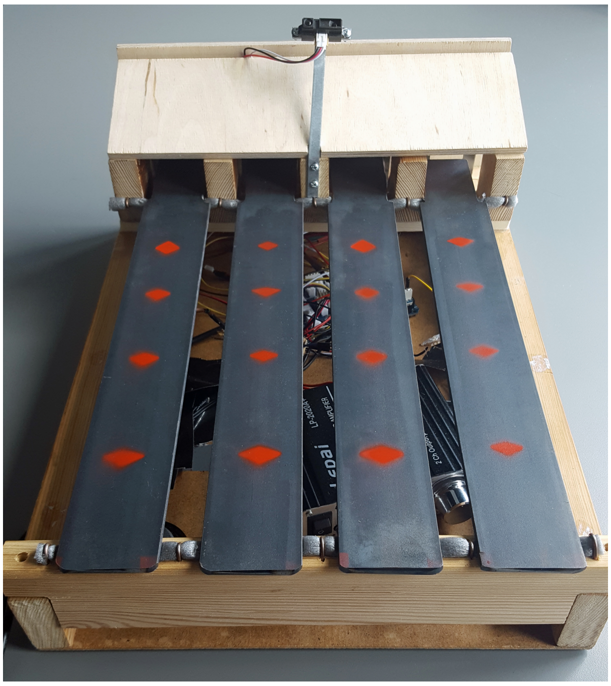

**Figure 1: Pitch Fork**

## 1. INTRODUCTION

Pitch Fork takes interaction concepts from pitched percussion, various members of the zither family of instruments, string instruments (particularly fretted string instruments) and the Theremin.

The instrument was designed so that someone with even a modest level of experience on a guitar like instrument would be able to adapt to the logic of the pitch mapping, and be able to quickly find musical patterns within it.

This interface should be of interest to professional musicians and keen enthusiasts who are fond of unusual and novel instruments.

## 2. RELATED WORK

The initial design concept for Pitch Fork placed the use of beaters, and their position tracking at the focus of parameter control. Instruments to then consider with respect to this include the Luma and The Radio Baton.

The Radio baton uses capacitive sensing to track the x, y and z coordinates of a baton, and this data can be processed to provide a trigger by registering sudden changes in velocity etc. [1].

The Marimba Lumina can make use of positional information about the beater, even while not in contact with the instrument, and use it for extra gestural control. [2] Such a design has to balance the extra possibilities of expression against the amount of free bandwidth available from the musician's brain.

Another early design concept was to try and harness ancillary movement as a sound control mechanism. It has been shown that the ancillary gestures of clarinet players do actually affect the tone of their instrument. [3] Through studying video recordings the author concluded that vibraphone players lean or hunch over their instruments to varying extents depending on their technique and expressive style. This observation led to the setting of the goal of leveraging this kind of movement for direct control of timbre.

Material Computation...

" *...can provide other computational operations such as band-limiting, resonance, smoothing that can be exploited to transform gestures from haptics into optimal acoustic energy.*"

This was the inspiration for the author to incorporate the use of a materials resonant and tactile quality into the process of controlling a digitally produced sound.



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# 3. DESIGN

Pitch Fork is meant to have the look and feel of a complete music instrument rather than being an interface alone. To that end the materials have been chosen so that they have acoustic properties of their own and invite playful interaction. Traditional metallophones (Gender, Vibraphone, Gamelan etc) tend to be comprised of numerous individually tuned metal resonators which are struck with a beater. Pitch fork differs from these instruments in that the four metal bars are cut to have very similar resonances so that any sound coming directly from them would be perceived as accompanying percussion rather than melodic content. The digital sound is also produced via transducers attached inside the wooden housing of the instrument. Ultimately the Pure Data patch at the heart of the machine will be run on a headless device such as a Rasberry Pi or, in the case of a Bela, the need for an Arduino could also be eliminated.

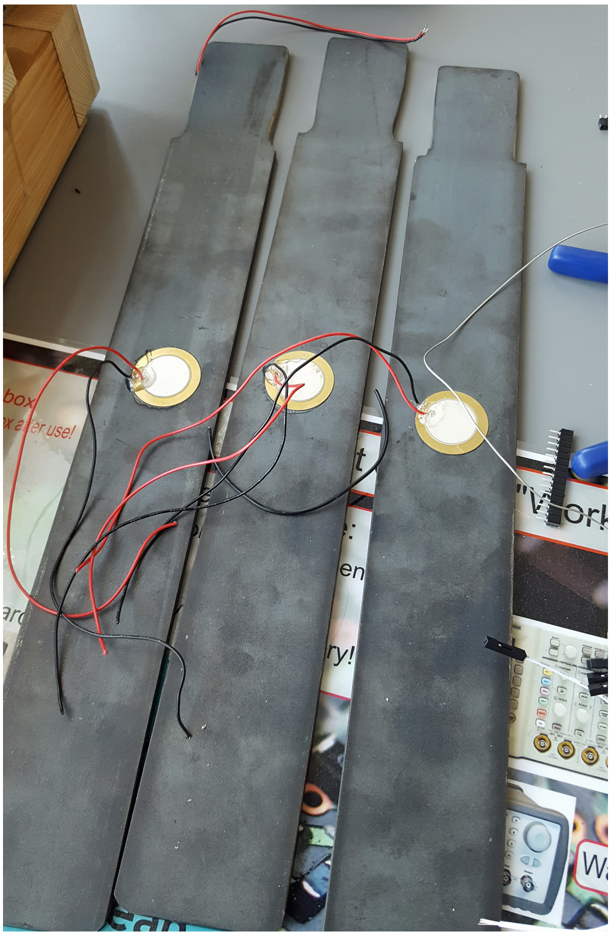

**Figure 2: Attachment of Piezo Sensors**

## 3.1 Mapping and Technique

Sound is produced in response to interaction between the performer and 4 iron bars (tongues) suspended on a wooden frame. The pitch is controlled by the position of the object interacting with the tongue, relative to the end of the tongue itself. The amplitude of the output signal is controlled by the output of the piezoelectric sensor attached to the bar being manipulated. The proximity of the player to the instrument (degree to which the player is leaning over the instrument) controls the energy of the signal (see Design/Sound).

At the time of writing Pitch Fork is most effective while the tongues are approached as flex sensors rather than simply striking them. Very expressive amplitude envelopes can be achieved in this way.

Aliquot markings on each tongue indicate the pitch mapping. The lowest achievable pitch is C4, nearest the player on the left most tongue. Each tongue has 4 aliquot markings, in a similar fashion to the strings and frets on a guitar, one aliquot marking (fret) corresponds to one semitone. Each tongue is tuned a minor third up from it's left neighbour. A diagram of the tuning of Pitch Fork can be seen in figure 3

The performer can use any combination of beater and direct hand contact that they wish. Applying constant or varying pressure to the tongue can produce a sustained note.

A diagrammatic representation of the mapping can be seen in figure 4

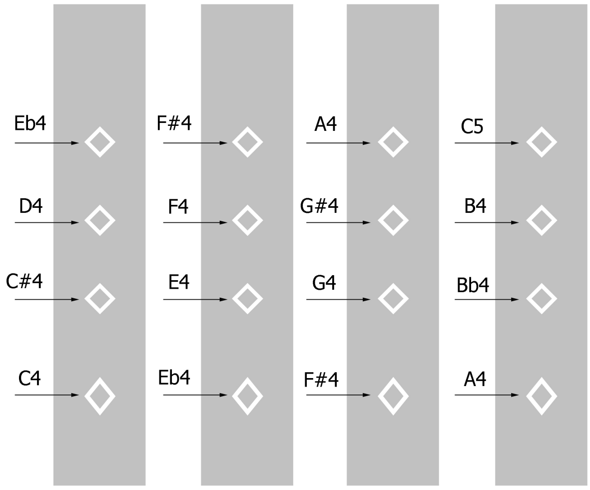


**Figure 3: Tuning Diagram for Pitch Fork**

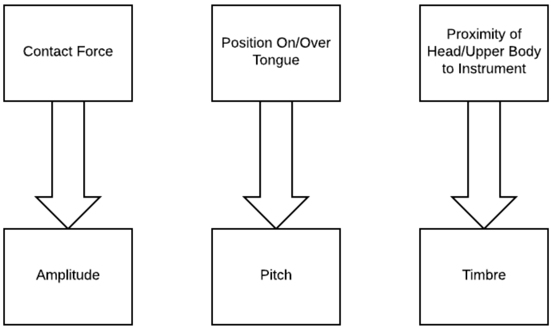


**Figure 4: Mapping Diagram for Pitch Fork**

## 3.2 Sensors

All sensors are connected to an Arduino Mega.

A Sharp GP2Y0A41SK0F (or equivalent) infra-red (IR) proximity sensor is positioned at the far end of each tongue, and covered by a wooden housing to reduce the interference from daylight. A fifth IR sensor is mounted on top of Pitch Fork and directed at the head of the performer.

A generic piezoelectric pick-up is adhered to the underside of each tongue with contact adhesive. The output of each is regulated by a Zener diode, and a burden resistor protects the Arduino from unwanted voltage spikes.

## 3.3 Sound

All sounds are built from a sine wave being sent through an *Energy Circuit*. The *Energy Circuit* patches add the first three even harmonics to the fundamental frequency. These harmonics are detuned slightly so that they are not perfect integer multiples of the original tone. This detuning increases as the effect is turned up. The final stage of the *Energy Circuit* is a distortion patch that was developed for a previous work by the author: Tromba Moderna. It models distortion in a stringed instrument by adding the first time domain derivative of a signal to itself. A small amount of reverb is then added. This sound is then effected by the process of transduction through the body of the instrument body.

# 4. EVALUATION

Evaluation of Pitch Fork is presented here from the three different perspectives of Audience, Performer and Designer. At the time of writing the instrument has only been working for a limited period of time and therefore only preliminary findings can be reported.

## 4.1 Audience

Sile O'Modhrain points out:
"*...the greatest challenge facing designer's of DMIs is that there is no longer a perceivable causal link between the gestures required to play the instrument and the mechanism that produces it's sound*"
This lack of transparency can present a barrier to expressive performance if the audience does not have a sense of the physical skill involved in playing the instrument. Even after limited testing it appears that observers can understand how the instrument is played, and are entertained by the spectacle of seeing someone play it.

The aspect of being able to lean in to the instrument and affect it's timbre was also noticeable and prompted a response from onlookers.

## 4.2 Performer

The use of unusual materials and novel construction captured the interest of potential players, and the pitch mapping and interaction mode were intuitive enough that people were able to quickly pick out simple melodies. Discussions with people that tried the instrument revealed that the primary feedback from the use of iron tongues was intriguing. Time spent by the author watching how vibraphone players lean over their instrument as an involuntary ancillary gesture seemed to pay off - leaning into Pitch Fork to change timbre seems intuitive, does not dictate the mode of expression, and can be 'hacked' by controlling the energy with a hand instead of body position. The instrument has 4 note polyphony, and reacts fairly quickly to player activity and allowing some degree of nuance in terms of dynamics and control of timbre. The notable restriction on expressivity is the fact that the instrument is limited to only one octave.

## 4.3 Designer

The goal of using material computation to control amplitude was only partially realised due to complications with the analogue circuitry involved. Due to ground hum and cross talk the signal from the piezoelectric sensors had to be low pass filtered and threshold-ed in order to give the controller more control over the audio output. This reduced the extent to which the resonance of the metal tongues could be used as a control parameter. However, the choice of material still affects the quality and nature of the interaction that the musician experiences. The IR sensors were similarly unreliable in their output, otherwise a finer pitch resolution would have been used, potentially giving the instrument a 2 octave range.

# 5. CONCLUSION AND FUTURE WORK

Pitch Fork is a novel digital interface and musical instrument which affords the performer expressive control over timing, dynamics, pitch and timbre. The electronics should be re-designed and built with more attention to potential interference and cross talk. As detailed in section 3.1, the current iteration responds most effectively to variation on continuous pressure rather than through striking. Future iterations should allow for this interaction whilst improving the instruments response to the striking technique it was originally designed for. The use of small microphones instead of piezoelectric sensors, and ultrasonic instead of IR sensors would be an interesting possibility to explore. Ultrasonic sensors have been used to good effect with other novel controllers such as Michel Waisvisz Hands [1] A more sturdy construction would allow portability.

# 6. REFERENCES


[1] M. M. W. Eduardo R. Miranda. *New Digital Musical Instruments.*

[2] D. J. Overholt. *Musical interface technology: multimodal control of multidimensional parameter spaces for electroacoustic music performance.* University of California at Santa Barbara, 2007.

[3] M. M. Wanderley and P. Depalle. Gesturally-controlled digital audio effects. In *Proceedings of the Conference on Digital Audio Effects (DAFX-01), Ireland*, 2001.