SoloTouch: A Capacitive Touch Controller with Automated Note Selector

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ABSTRACT
This paper describes the design of a guitar-inspired, pocket-sized controller system *SoloTouch*. *SoloTouch* consists of a capacitive touch trigger, and an automated note selector program. Requiring only one finger, the touch trigger allows intuitive execution of both velocity sensitive notes and aftertouch messages. The automated note selector program selects consecutive consonant notes from preprogrammed solo phrases. A companion iPhone app displays and controls the phrases that are being performed. The interface focuses on the balance between ease of playing and the degree of expressive controls available. Players without prior musical training could perform musical and expressive solos suitable for improvisational contexts in the style of blues and rock.

Keywords
Capacitive touch controller, automated note selector, virtual instrument MIDI controller, novice musicians.

1. INTRODUCTION
Novice musicians are often discouraged by the many difficulties in learning a musical instrument, especially before they reach a point where they could enjoy the pleasure of playing interesting and expressive music beyond drills and scales. We designed a MIDI musical controller interface that reduces technical difficulties to a minimum, while providing players with the possibility to project their musical expression into the music. We have simplified the trigger controller mechanism so that controlling expressive parameters is as easy as touching a surface. The automated note selector program helps player decide what notes to play. Rather than learning and memorizing notes and scales during performances, players focus on how the notes are played and musically expressed with the trigger controller. A companion iPhone app is designed to enhance the musical variations of the *SoloTouch* experience. The *SoloTouch* is specifically designed to trigger electric guitar samples through MIDI, though it could be used to trigger other instruments.

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2. DIFFICULTIES IN PLAYING MUSICAL INSTRUMENTS
This section discusses the two main difficulties that novice musicians face when attempting to play music on a melodic musical instrument. These difficulties are as follows:

1. Players do not know what notes to play (note selection).
2. Players find it difficult to control the expressive parameters of the notes executed (expression control).

2.1 Note Selection
2.1.1 Difficulty in selecting the "right notes"
Melodies in Western music are organized around keys and scales. Beginner musicians are unlikely to come up with consonant sounding melodies independently if they do not know the notes of a pre-existing composition, or have prior training in improvisation and/or music theory. To learn and memorize notes on a new instrument, and know how to effectively execute them in an organized manner is difficult to start with. Many beginners give up on an instrument before they could play the songs that they desired to learn.

Selecting the "right notes to play" is one of the more difficult choices to make for a beginner instrumentalist or improviser. One way to tackle this problem is to remove dissonant intervals in a scale, and limit the musical possibility to those pitches that sound like the "right notes" to play.

Playing just the white notes on a piano keyboard is essentially the same as playing only the notes in the C major scale. Novice pianists often find playing melodies in the C major scale easier than any other scale as there is no confusion over counting intervals with the black keys. The player is confined within a single modality. Limiting the number of playable notes is a good way of encouraging beginner musicians to explore with confidence.

2.1.2 The Pentatonic Scale
The pentatonic scale is a common scale that is used all around the world. Due to the modality's lack of the most dissonant intervals, it is also used in a range of music pedagogy settings. Any pitch of the scale may be played in any order or combination without resulting in excessive dissonance. The scale allows beginners to improvise without being discouraged by dissonant intervals. A large number of popular rock, jazz, and blues solos are based mostly, or entirely, on the pentatonic scale. A reason for its popularity in modern music genres is the fact that the scale is highly compatible with both major and minor keys (the two mostly used keys in western music). Limiting playable notes to only the pentatonic scale may allow

rock and blues-like melodies to be emulated with ease, without the fear of executing the "wrong notes."

2.1.3 Automated Note Selection

One way of using technology to assist novice musicians with note selection is to program a set of notes that would be played by the player in a computer program, and allow each note to be played consecutively by activating a trigger. This method had been shown in Max Mathews' Radio Baton [1] and Radio Drum [2] where each tap of the stick or baton triggers a note or a small musical phrase from the preprogrammed score. Rather than having control over the notes selection, players could use the batons to control the tempo and dynamics freely without any concern over playing wrong notes. This method successfully removes the technical challenge of playing the "right notes" in a song. But the disadvantage is that players would be limited to only the preprogrammed scores, removing some of the expressive and creative aspect of music playing.

The *SoloTouch* system is built upon the idea of automated note selection, it is modified to allow more creative controls over the music to be played. By dividing the music to be played into shorter phrases, *SoloTouch* allows the player to make choices in selecting which preprogrammed music to play in a phrase-to-phrase basis. By combining different preprogrammed phrases with infinite rhythmic variations, there is no limit to the music that could be played by the *SoloTouch* (See Section 5).

2.2 Expression Control

Apart from the notes that are played, variables such as dynamics, articulations and pitch enhance the expressiveness of musical performances. However, controls of these variables are often somewhat difficult to master. This is especially true when multiple expressive variables are mapped to separate limbs and gestures, such as pitch bending with the left hand while the right hand plays a note on a piano keyboard. The splitting of limb controls increases difficulty to the expressive control of music playing both physically and mentally. The *SoloTouch* controller is designed to combine multiple expressive variables into single motions on a limb (See Section 4).

3. CAPACITIVE TOUCH CONTROLLER

The *SoloTouch* system consists of a capacitive touch controller used to trigger consecutive notes in the automated note selector program. The controller makes use of the capacitive touch technology to play velocity sensitive notes and aftertouch messages by touching and pushing the metal plate surface respectively, allowing an intuitive way to control expressive variables such as dynamics and pitch modulation with a single finger movement. We put a strong focus on the physical ease of execution, and on the simplicity of the motion to be mastered both physically and mentally.

Similar design of a hit surface acting also as a note trigger controller was seen on Max Mathews' *Radio Drum* and *Radio Baton*. In these devices, a stick or a baton hitting a surface will trigger one or a series of MIDI notes, depending on the location of the point of impact on the hit surface [1, 2].

However, unlike the Radio Drum, the ability to select different notes from a musical palette is not important in the touch controller as it is designed to be used alongside an automated note selector program, which will be further explained in the Software section of the paper.

4. HARDWARE DESIGN

The *SoloTouch* capacitive touch controller uses a Seeeduino Film as its core, with a combination of a capacitive sensor and a flex sensor as the main inputs. The controller messages are sent wirelessly through Bluetooth communication, into a computer that in turn drives the automated note selector program.

4.1 Sensors and control mechanism

4.1.1 Capacitive Sensor

The main input of *SoloTouch* is a 6cm by 6cm metal plate, which acts as a capacitive sensor that is activated by the physical contact between a player's finger and the plate's surface.

The use of capacitive sensing as a musical input has been around since the introduction of the Theramin. Various musical instruments presented in previous NIME proceedings made use of capacitive touch sensing as the basic input of the instrument. These include *the Snyderphonics Manta* [3], a touch sensitive isomorphic hexagonal keyboard; and the *Instant Instrument Anywhere (IIA)* [4], a small device which can be attached to any metal object to create an electronic instrument. A few augmented instruments based on traditional instruments also used capacitive sensing as an additional expression input. Some examples include the piano based *TouchKeys* [5], which added multi-touch sensing to each piano key expressed as aftertouch messages; and a left hand gesture caption system for the guitar, which uses capacitive sensing methods to capture physical gestures on a guitar [6]. Although resistive touch sensors are more common and readily available than capacitive touch sensors, resistive touch sensors are far less sensitive than their capacitive counterpart, they also require a certain amount of push force to actually trigger the touch.

We used the CapSense library[1] for the Arduino platform to detect relative capacitance, and the speed at which the capacitance is charging. Reading increases with the surface area of finger contact. We mapped this reading to the velocity of the notes triggered. A forceful touch with a high level of physical contact will trigger a high velocity note-on, and vice versa. This way, a player is able to not only trigger notes, but also to control the dynamics of the notes performed.

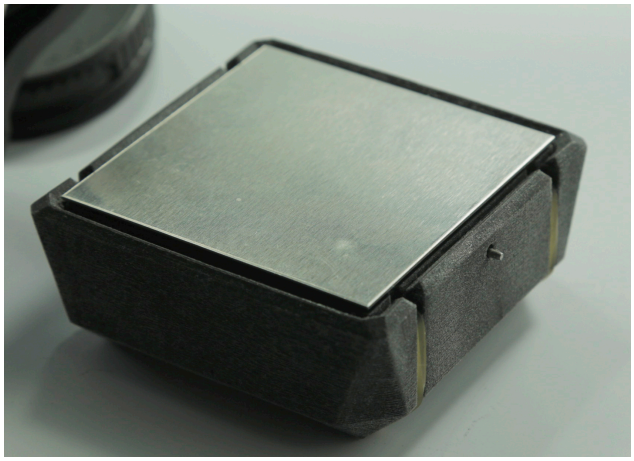


Figure 1. SoloTouch controller featuring a metal plate as capacitive sensor.

4.1.2 Flex sensor

A flex sensor is attached to the bottom of the touch surface to detect the tilt of the plate. A central shaft axle that goes through the plate secures the surface onto the controller enclosure. The touch plate swivels when the finger pushes it. Two rubber bands are fixed under the touch plate on both sides. A push on the touch plate in either direction is marked by a tension feedback. The flex sensor gives an aftertouch message, which could mapped to pitch bends, vibrato, volume modulation or other expressive variables.

[1] http://playground.arduino.cc//Main/CapacitiveSensor

The tension caused by the rubber bands proved to be ideal in mimicking the string tension of bending stings on a guitar.

Figure 2. Pushing the touch plate sends aftertouch message useful for mapping to expressive variables.

4.2 Processor and Communication

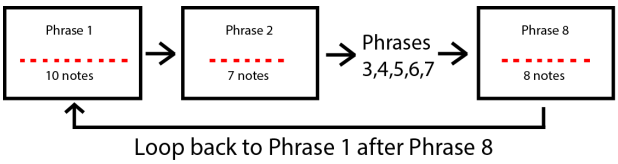
The controller is powered by a Seeeduino Film[2], a flexible Arduino compatible circuit board that fits inside of the enclosure. The film works in combination with a Bluetooth frame module that allows wireless communication with the computer running the automated note selector program and software sampler. Serial messages sent via Bluetooth are converted to MIDI via the Hairless MIDI to Serial Bridge.[3]

5. SOFTWARE

The *SoloTouch* system works with a Max/MSP patch that is responsible for note selection. It processes the player's input and outputs MIDI messages to a software sampler. In our prototype we specifically implemented an electric guitar sample library with the aim of emulating improvised guitar solo.

5.1 Automated Note Selection Program

Touches on the capacitive controller trigger consecutive notes from a set of preprogrammed phrases. A total of phrases will be played in succession. When all the phrases have been played, the program loops back to the first phrase automatically.



■ = Notes to be played by tapping on the capacitive surface

Figure 3. Notes will be played from one phrase to another.

All notes in the phrases are selected from the pentatonic scale, to minimize the dissonance even when notes are played in an unorganized manner. To add musical variations, each of the eight phrases features four alternative versions. We call these alternative versions "styles." Each "style" has its own unique sequence of notes. Users may create unique sounding solos by combining phrases of different styles.

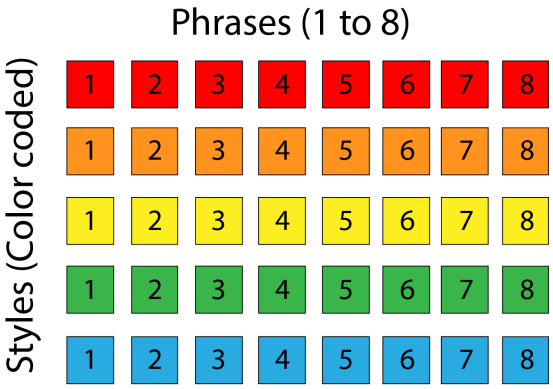


Figure 4. Visual representation of the phrase and style concept used by the SoloTouch system.

Figure 4 shows a diagram with phrases represented as boxes numbered from left to right, and five "styles" color-coded red, orange, yellow, green and blue. By default, notes are drawn from the same color. For example, when all the notes in red 1 have already been played the system moves onto red 2. Players may command to switch into another style, but this would only happen at the end of the current phase progression. There are a total of 40 preprogrammed phrases.

5.2 Companion iPhone App

A TouchOSC[4] based companion iPhone app, built with the TouchOSC layout editor, is designed to allow for style and key switching, and to give visual indications to assist the playing of *SoloTouch*. The companion app is optional to the *SoloTouch* experience, as the capacitive touch controller can be played alone if the player does not intend to switch phrase styles or to change keys.

The companion app consists of two pages, the Play screen, and the Change Key screen, where style switching and key changing can be performed respectively.

Figure 5. Companion iPhone app with SoloTouch controller

5.2.1 Phrase indicator

The Play screen of the app shows two colored wheels that act as indicators to the position of the phrase and note currently played on the touch controller.

[2] http://www.seeedstudio.com/wiki/Seeeduino_Film
[3] http://projectgus.github.io/hairless-midiserial/
[4] http://hexler.net/software/touchosc

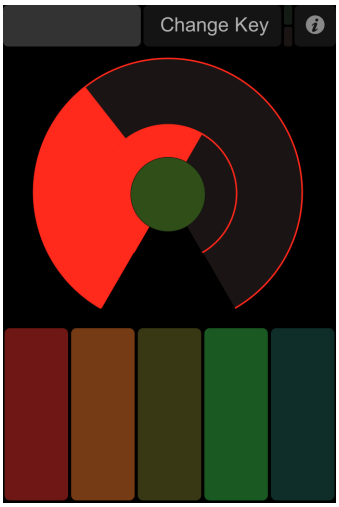


Figure 6. Play screen of the companion iPhone app.

The outer wheel, dubbed the Phrase Wheel, shows the phrases number of the currently playing phrase, which ranges from 1 to 8 as mentioned in earlier sections. Each time a phrase progresses to the next, the colored fill of the Phrase Wheel moves up by one slot clockwise, with a total of 8 slots in a fully filled wheel.

The inner wheel, dubbed the Note Wheel, shows the number of remaining notes in the current phrase. The wheel starts off fully filled with the active style color until less than 8 notes are left in the phrase, then the fill moves down by one slot anticlockwise for every note played. When the last note is played, the wheel should have no fill, until it progresses to the next phrase, when the wheel will be fully filled again.

5.2.2 Style Changing

Players can switch phrase styles by tapping on a colored tab at the bottom of the screen. When a colored tab is pressed the center of the inner wheel would change to the selected color, indicating that the next phrase will changed to that color in the next phrase progression.

When the last note of the current phrase is played, the indicator wheels will turn to the selected color, meaning that the player will be playing the set of notes from that style.

It is worth noting that the player is free to tap on any colored tab at anytime without any immediate effect, the style change will only occur during phrase progression, the color last shown in the center will be the one that affects the style switching.

5.2.3 Key Changing

By tapping on the Key Change tab on the Play screen, the app will switch to the Key Change screen, where players can change the scale key that *SoloTouch* will play.

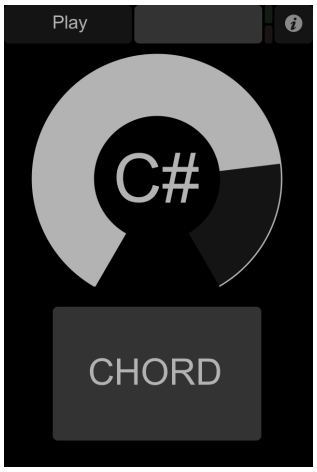


Figure 7. Key Change screen of the companion iPhone app

The white wheel, dubbed the Key Wheel, enables fast switching of keys by scrubbing on the wheel. Players can set from the key of E all the way up to Eb with every other key in between.

To preview the sound of the selected key, press the Chord button under the Key Wheel to listen to a chord sample of that key. This is useful for matching the key of *SoloTouch* to the key of a backing track.

When the player has chosen the desired key, the Play tab on the top returns the app to the Play screen.

5.3 Software Sampler

The *SoloTouch* controller system is tested specifically with an electric guitar sample library Prominy LPC Electric Clean Guitar[5], running on Native Instruments Kontakt 5.[6]

The sample library features clean recorded electric guitar samples that could be amplified by an amp simulator. We used Native Instruments Guitar Rig 5[7] to amplify the guitar sound to emulate the tone of a real electric guitar.

The library also has an "auto-sustain" feature where a note-off message will not stop the sustain of the played note until the next note is played, this makes tapping on the *SoloTouch* controller play long sustained notes rather than an immediate stop when the finger lets go of the controller surface.

Aftertouch messages are mapped to trigger the real guitar vibrato recorded in the library. Pushing down on the SolosTouch sensor plate translates to the vibrato performed on the virtual guitar. This results in a satisfactory emulation of string bending vibrato action on the *SoloTouch*.

6. FINDINGS

This section describes the many findings that were found from testing the *SoloTouch* prototype with individual candidates.

6.1 Techniques

Although the *SoloTouch* can be played by any gesture involving physical contact between the capacitive sensor and the player's body, it is found that tapping on the metal surface by alternating the index and middle finger, most easily plays the *SoloTouch*. The motion, similar to finger picking on a bass

[5] http://www.prominy.com/les.htm

[6] http://www.nativeinstruments.com/en/products/komplete/synths-samplers/kontakt-5/

[7] http://www.nativeinstruments.com/en/products/komplete/guitar/guitar-rig-5-pro/

guitar, makes use of the flexibility and dexterity of the two fingers. We have made a demo video showing the ease of playing complex sounding guitar solos using entirely this technique on the *SoloTouch*.[8]

Although the automated note selector program already takes care of the note selection part of the playing, the rhythm of when each note is played is entirely dependent on the player's performance. Playing the same notes in different tempo and rhythmic patterns creates very different sounding musical phrases. Similarly, playing the same rhythmic patterns on different phrases would again result in very different sounding solos patterns. This results in a high level of musical expressiveness to the player, the instrument encourages players to develop a sense of rhythm and to discover more rhythmic patterns to enrich the musical variations in playing the *SoloTouch*.

Tested individuals also showed that the Note Wheel indicator in the companion app improves their playing by showing when the last note of the phrase would be played. Ending a bar with the last note of the phrase usually sounds more consonant than any other note in the sequence. Adjusting the rhythmic pattern accordingly to fit the last note of the phrase to the ending note of a bar is a common technique players develop once they understand the phrase concept.

6.2 Improvisation

Although all the notes and phrases in the automated note selector program are all preprogrammed and constant, the *SoloTouch* is mostly used as an improvisation instrument where the player would play without knowing what the next note of the phrase could be.

Improvising on other melodic instruments often require much training in musical knowledge to achieve satisfactory results, with the *SoloTouch* the experience of improvising music becomes much more accessible to novice musicians lacking sufficient musical knowledge.

6.3 Limitations

The *SoloTouch* is capable of playing unique sounding blues/rock sounding guitar solos with endless possibilities in rhythm and phrasings. The use of only notes from the pentatonic scale successfully removes potential dissonance of other notes in the chromatic scale. However the disadvantage is that the music produced by the automated note selector program, even when played on different rhythmic patterns, mostly sound melodically similar in terms of the scale use. This also made the *SoloTouch* limited to creating melodies in genres that uses the pentatonic scale extensively.

Another limitation to the capacitive touch controller is that when played with the sampler's "auto-sustain" feature on, which renders the note-off message unusable, there is no way to stop the played sample other than to wait for the decay of the sound to end. This makes playing short notes with the "auto-sustain" feature impossible in the current hardware setup.

7. CONCLUSION

The *SoloTouch* is a hardware-software integrated system that allows improvised performance of blues/rock sounding guitar solos to be more accessible to novice musicians. By combining a simple capacitive touch controller and an automated note selector program, players can play notes in any rhythmic patterns without the risk of landing on dissonant sounding notes. The interface focuses on the balance between the ease of expressive playing and the degree of musical expressiveness available. An optional companion iPhone app is built to add more controls to the musical variations and the playing key, enhancing the *SoloTouch* experience.

8. FUTURE WORK

Improvements over the automated note selector program could be made to play notes outside the pentatonic scale while keeping musical dissonance to a minimum, this would allow the *SoloTouch* to play more different sounding phrases and to extending the musical palette, while keeping the system simple and easy to understand.

Currently the *SoloTouch* is specifically designed for use with playing an electric guitar sample library, more possible application could be tested in future development. For example, to use the capacitive touch controller in combination with a MIDI controller keyboard to control string vibrato normally played with pitch wheels, or to use the push mechanism of the touch plate as an audio effect controller.

Another improvement to be made is to add an extra capacitive touch surface for the thumb at the side of the controller, as a stop/mute key for use with the auto-sustain feature in the sampler.

As the interface puts a strong focus on the ease of playing for novice musicians, any future addition or modification to the hardware or software should not make the SoloTouch anymore difficult to play than the current version.

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[8] http://www.vimeo.com/66205842