ThumbTec: A New Handheld Input Device

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ABSTRACT

This paper describes ThumbTEC, a novel general purpose input device for the thumb or finger that is useful in a wide variety of applications from music to text entry. The device is made up of three switches in a row and one miniature joystick on top of the middle switch. The combination of joystick direction and switch(es) controls what note or alphanumeric character is selected by the finger. Several applications are detailed.

Keywords

One-Thumb Input Device, HCI, Isometric Joystick, Mobile Computing, Handheld Devices, Musical Instrument.

1. INTRODUCTION

Together, the mouse and keyboard have remained the industry standard for the personal computer. The standard keyboard is ideal for the desktop computer, but hardly an adequate solution for mobile computing, where size and portability are of utmost importance.

Nevertheless, most attempts at designing a suitable interface for handhelds have used some sort of keyboard. However, the keyboard works best when all the fingers of both hands are used. Each finger is responsible for a certain area on the keyboard and typing is quick and efficient. This paradigm does not work that well for one or two thumbs. The keyboard foot print is large, while the keys are usually small and close together. Because of this, the user must focus their attention on the keyboard to avoid making mistakes, which can slow progress. In order to type faster both hands are usually used. Thus, handhelds become bi-manual for text entry. Although stylus-based interfaces have a significantly smaller footprint than the keyboard, both hands are needed and typing can be quite slow. There is a third category for text entry, namely the predictive technique like the T9 in cell phones. This technique works quite well with the cell phone keypad. However, it requires lots of storage and is language specific [3].

Therefore, there is a need for a one-thumb input device for text entry. The ThumbTec is a novel input device that attempts to solve most of these problems and can also be used as a pointing device. It can make selections quickly, efficiently and unambiguously and can be as small as a fingerprint. These features make it ideal for handheld devices from cell phones to graspable musical instruments.

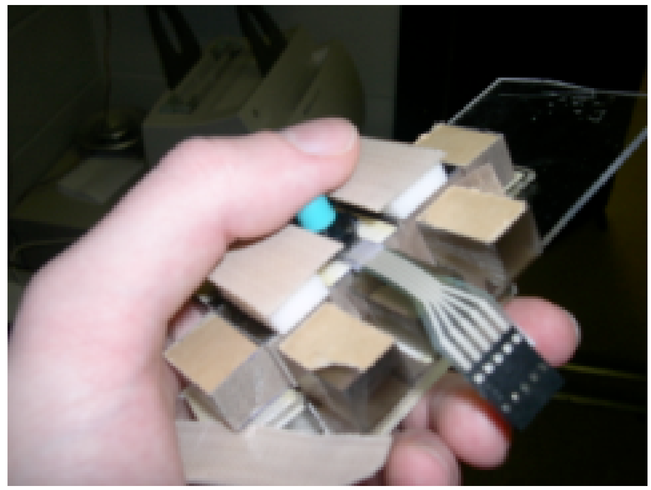

Figure 1. ThumbTec Prototype

2. DESIGN

Several electronic musical interfaces have been based on acoustic instruments. Although it is important to study acoustic instruments extensively, there are fundamental differences between acoustic and electronic instruments that may have been overlooked. When playing an acoustic instrument, such as the piano for example, the finger must move to the location of the desired key in order to play it. When playing an electronic instrument the physical model is inside the computer. There is no need to move the thumb or finger to another location in order to select a particular note. With the ThumbTec the finger or thumb can make note selections while staying in place.

The ThumbTec was initially designed for music with the idea that very subtle thumb gestures could be used in order to select pitches in an electronic instrument. The major challenge is making sure that these gestures are unambiguous, efficient, natural and easy to learn. The first step in this challenging process is to really understand what gestures are natural for the thumb. Video game controllers demonstrate that it is very intuitive for the thumb to push a joystick and press down on buttons. The second step is using this insight to build an interface that is unambiguous. Choosing forward, backward, left and right as the only directions that can be selected by the thumb seem like the most natural choice. Push buttons switches that make a "click" when pressed are the most obvious choice for sensing downward pressure. The clicking is important because it gives the user tactile feedback. The ThumbTec was designed with this in mind.

Figure 3 a) shows a side view of the ThumbTec. One switch is placed in front of the joystick, the other in back, and a final switch would be placed beneath the joystick. The thick black horizontal lines are panels that are placed on top of the push button switches. The switches are represented by the boxes below the panels. An "X" inside the box indicates that the switch is turned on or depressed by the thumb. Figure 3 b) shows a top view of the ThumbTec. The three squares are the panels. An "X" inside these boxes indicates that the switch below the panel is on. The term "clicked" will be used from now on when describing when a switch is turned on. Figure 3 c) through h) shows all six possible switch combinations that can be simultaneously clicked by the thumb. Both a top view and a side view are shown for each of these combinations. It is important to note that the thumb is always in contact with the joystick. While clicking the front switch, as in Figure 3 c), the finger can simultaneously push the joystick North, South, East or West. This is true for all six different switch combinations. When the joystick direction is factored in, the number of different simultaneous joystick/switch combinations is 24.

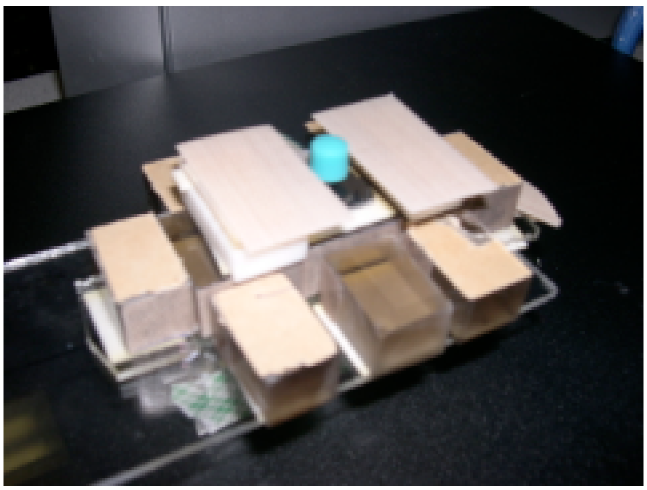

Figure 2. ThumbTec Prototype

2.1 Single-Click Technique

The single-click technique describes when the thumb pushes the joystick in a direction (N, S, E or W) while simultaneously clicking either one, two or all three switches. Clicking on the middle and back switches, as in Figure 3 f), while pushing the joystick E, would be just one example of the single-click technique. Figure 4 shows all 24 of these single-click techniques. The arrow inside the circle indicates the direction of the joystick, while the X's inside a box indicates that the switch is clicked. The positive or negative number below every permutation, namely the interval jump, will be explained in the next section. In this section the interval jump number will be used as a name identifying a particular single-click technique. The technique is called single-click because the thumb presses down on the switch(es) once.

2.2 Double-Click Technique

The double-click technique can be thought of as a single-click technique preceded by a switch combination without a joystick direction. In other words, the thumb would first choose one of the six switch combinations without pushing the joystick in any direction, then would select a single-click technique from Figure 4. For example, the front switch could be clicked, as in Figure 3 c), and then the single-click technique named +5 from Figure 4 could be selected. The total number of double-click permutations would be found by multiplying 6 by 24 giving a total of 144. Adding the 24 single-click techniques would give 168. This gives a total of 64 more options than the standard computer keyboard at the tip of a finger.

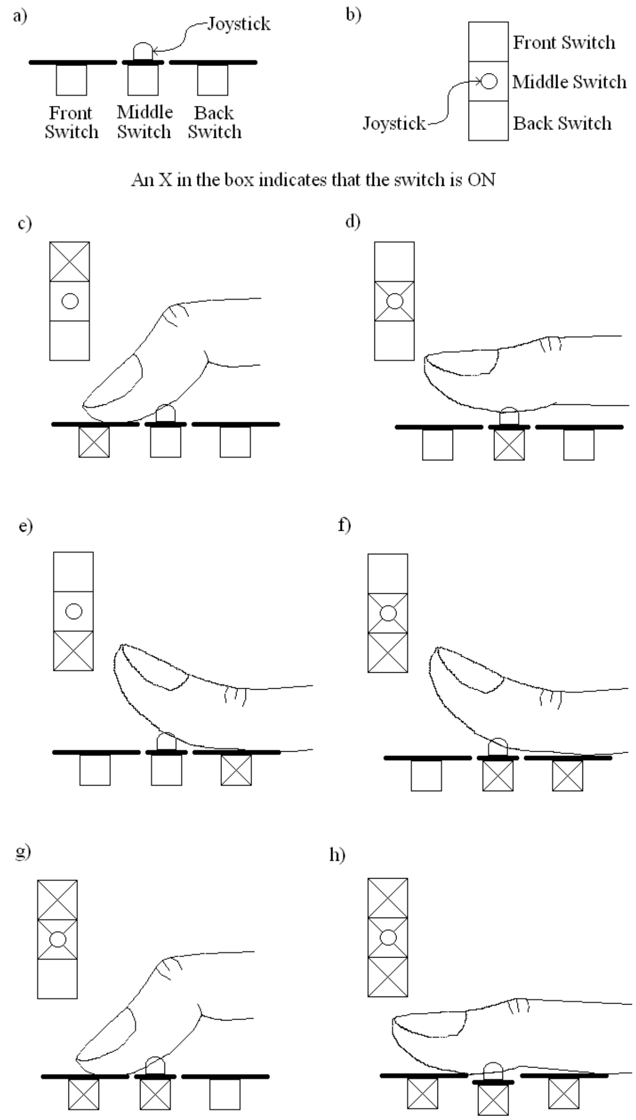

Figure 3. All Possible Switch Combinations

3. MUSICAL APPLICATION

This section describes the application of the ThumbTec interface as a monophonic and polyphonic instrument, as well as applications in both acoustic and electronic instruments.

3.1 Monophonic Instrument

As discussed in the previous section, there are 24 single-click techniques. Figure 4 lists all 24 single-click technique permutations in a graphical manner. The arrows indicate the direction of the joystick, while the X's indicate when a switch is clicked. The positive/negative number below each single-click technique graphic is the interval jump. The interval jump is simply the number of semitones to go up or down from the current note played. +1 would mean go up one semitone, -4 would mean go down four semitones, all relative to the current location. One major advantage of an instrument that uses relative intervals is that the pattern for a particular scale is the same regardless of the starting note. Take the major scale: C, D, E, F, G, A, B, C'. If we assume that we are currently on note C then to get to D we would go up two semitones, or +2. D to E would also be +2, and so on. Using this relative interval approach, the pattern would be +2, +2, +1, +2, +2, +2, +1. This pattern would be the same for all major scales, which is quite different from the piano, which has a different white/black key pattern for each major scale.

3.2 Mapping Rationale

If one looks closely at Figure 4, one would notice that the switch combination for each negative/positive pair, like +4/-4, is the same. The only difference between each negative/positive pair is the direction of the joystick. Taking +4/-4 as an example, we notice that both have the middle and back switches clicked but that +4 has the joystick poiting N, while -4 has the joystick pointing S. In fact, the joystick is always pointing in the opposite direction for each positive negative pair. The intervals are also organized in terms of size. All the small intervals, namely +1 to +6 and -1 to -6, have joysticks pointing N or S. In other words, all the small intervals have a joystick direction that is on the same vertical axis. While all the big intervals, namely +7 to +12 and -7 to -12, have their joystick directions on the horizontal axis. This kind of organizational scheme was designed to make learning, remembering, and performing the intervals as intuitive as possible.

3.3 Polyphonic Instrument

If the thumb and fingers each have a ThumbTec, they would potentially be able to make selections from the list of intervals in Figure 4. In this context the thumb could play the melody while the fingers could play the accompaniment. However, the interval selections by the fingers would always be relative to the melody. Let us again take our C major scale: C, D, E, F, G, A, B, C'. Let us assume that we are playing C, E, G, with the middle finger, index finger, and thumb respectively. G is assumed to be a note in a melody, while C, and E are the accompaniment. In order to play this accompaniment, the index finger would select -3 because E is three semitones lower than G, while the middle finger would select -4 because C is four semitones lower than E. Each finger is relative to one another, but it is the thumb that is at the top of this chain. The electronic circuit and software used to interpret the musicians actions would be designed such that, if the thumb and fingers each make a selection at the same time it would know to play a chord. The thumb would decide the next note, while the fingers would decide the notes of the chord. Again, this pattern would be the same for all major chords with the thumb as the leading note. Thus learning might be easier as each particular accompaniment would always have the same pattern. It is interesting to point out that the interval between each finger can be as much as an octave. Thus the thumb and fingers of the hand could actually span as much as four octaves.

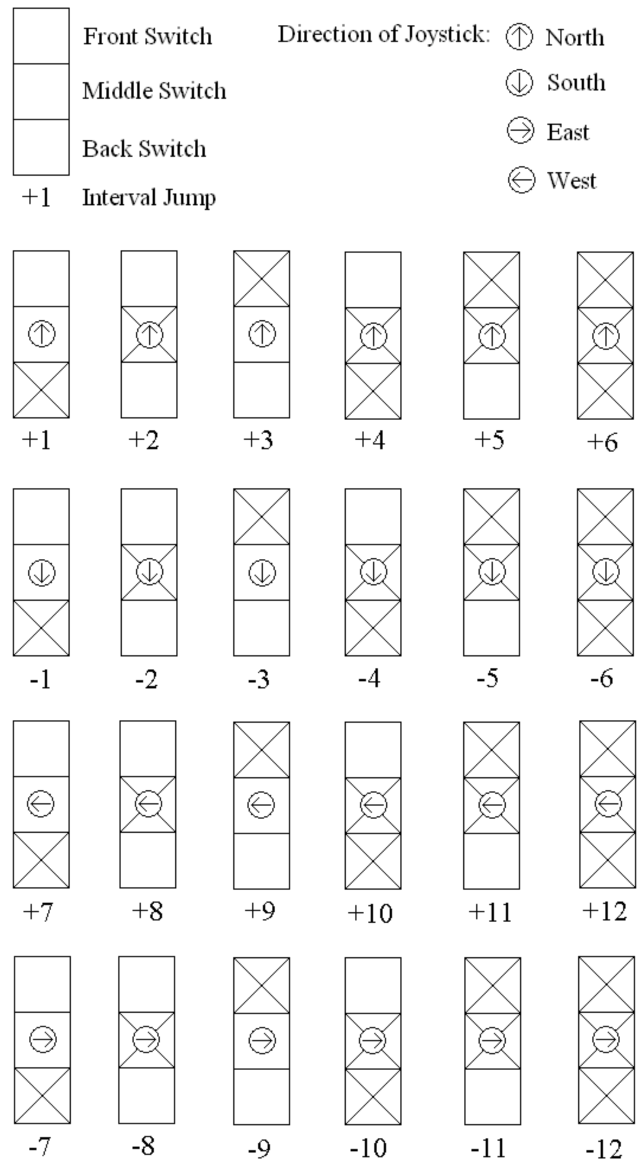

Figure 4. All Possible Single-Click Permutations

3.4 Vibrato, Volume, Glissando

Selecting pitches or intervals has been described in detail in the previous paragraphs. However, many musical instruments, like the violin can perform vibrato, control volume and glissando of the note being played. The joystick (without clicking any of the switches of course) is ideal for controlling vibrato and volume. Forward and backward motion of the joystick could control the volume, while side-to-side movement could control vibrato. The initial loudness of the note could be controlled by how hard the joystick is pushed when selecting a note. Gliding from one note to another smoothly and continuously could be done by the amount of force applied to the joystick during note selection. For example, to go from C to D in a smooth and continuous manner, the musician would select +2, but apply or build the pressure on the joystick gradually after clicking down on the middle switch (see Figure 4). The more pressure applied to the joystick, the closer to D one would get. Once the pressure reaches a certain threshold the circuit and software would recognize that the motion is finished, and you would now be precisely on D. Thus the musician would be able to control the rate of the glissando with the pressure applied to the joystick during note selection.

3.5 Application In Other Instruments

ThumbTec's small footprint makes it an ideal addition to extended instruments. For example, two ThumbTec devices could be added beneath the thumbs on a saxophone along with a pitch detector near the bell [1]. The thumbs would choose what notes to play relative to the saxophone. In this configuration the musician would create a polyphonic saxophone able to play three part harmony. This kind of setup would suit instruments where the musician has one or two fingers that are idle [2]. In the case of the trumpet, the free hand would enable six part harmony. In the case of a slide guitar, the slide could be outfitted with up to five ThumbTec input devices allowing the musician to play a wide variety of sliding chords. The vBow and Hyperbow are prime candidates for this technology as well[4],[5].

4. CONCLUSION

The ThumbTec project indicates that, although research in alternate and instrument-inspired interfaces is very important, exploring other interface paradigms can lead to interesting results as well. Future scientific research is needed to compare the effectiveness of the ThumbTec with other text entry methods. Feedback from musicians concerning the ease or difficulty of learning to play an instrument based on relative notes is also of great interest.

5. REFERENCES

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