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# Auditory and Tactile Information Perception

Aswathy Sunil, Deepika Ashok, Franklin Jessie Theresa

Professor L.Jabasheela, Department of Computer Science and Engineering, Panimalar Engineering College, Chennai, India.
Asst.Professor R.Devi, Department of Computer Science and Engineering, Panimalar Engineering College, Chennai, India.

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***ABSTRACT—*** *The proposed arrangement is an interactive system which aids blind and visually impaired people by conveying visual information via auditory and tactile methods. Users can traverse a two dimensional layout displayed on a touch screen, using their fingers while simultaneously receiving auditory instructions. The primary source of notification used here is sound which is also used for object localization, identification and shape. On the other hand, touch is used for kinesthetic feedback and pointing. In addition to the proposed theories, raised dot tactile patterns can be included to the system. For other features, the head related transfer function is used for sound directionality, sound intensity and for rendering proximity. The main objective is to dispatch the objects shape but it becomes more complex with scenery. So, each of the components is given a distinct tapping sound – "virtual cane". The concluded project validates that the raised dot patterns show the best static shape rendition, while spatial sound is used for dynamic display. The proposed configurations outperform the ones in practice. It is also expected to be incorporated into other applications where visual perception is not possible.*

**Keywords—** Sensory substitution, kinesthetic feedback, audio- tactile representation, spatial sound.

## 1. INTRODUCTION

The pervasive nature of mobile computing and the various types of media present online nowadays has become a difficulty to the BVI community, often alienating them from the data available. While some of this data can be either speech or Braille message, the capacity to show graphical and pictorial data in an acoustic-material frame will significantly give more information to the BVI community which is demonstrated in this project. The fundamental idea is that the client effectively investigates a two-dimensional design of at least one shape on a touch screen, utilizing the finger as a guiding gadget that gives kinesthetic input, and sound-related criticism in the virtual space. An overlay of raised-spot material examples or a straightforward piezo-dynamic polymer can likewise be included to give more information. Vibration input can also be coordinated in the touch-screen device to provide additional data to the output. The concentration of this paper is on identifying the state of a basic shape in either object or scenery format. Each object can be indicated on a touch screen with a trademark sound. In any case, we consider the rendering of a basic scene design comprising of articles in a direct course of action each with a particular tapping sound, which we contrast with a "virtual cane." The upside of using visual substitution techniques, whereby listening and touch are utilized as a part in the place of vision , is that they dont require obtrusive methodologies, which ordinarily oblige surgery to animate the visual cortex. A settled visual substitution approach is Braille, which depends on touch to feel an assortment of images. While not requiring surgery, some visual substitution methodologies can, in any case, be very offensive. The tongue display comprises of a variety of electrodes that can apply diverse voltages to fortify the tongue, which is the most delicate material organ with elevated spatial determination. However, the

BVI populace discovers it very “intrusive” and likes to effectively filter/investigate with the finger, as they are accustomed to doing in Braille. The wide accessibility of element material detecting gadgets (tablets, tablet PCs, mobile phones with touch screens) empowers the presentation of dynamic acoustic signals in response to finger movements.

Other unpopular techniques include the presentation of electrical and other material boosts on different parts of the body like the back, midriff, and brow.

Static tactile signals can be included by superimposing a raised-dot design embossed on paper (utilizing a Braille printer) on the screen, as in the "Talking Tactile Tablet" (TTT).There are various smart phones or tablets with touch screens that give dynamic vibro-material criticism, by means of either engines or Piezoelectric components, and apply to it kinesthetic and sound-related input. In this project, our essential concentration is on audio notifications. However, we consider the superposition of raised-dot patterns embedded in a paper as well.

A definitive objective of the proposed approach utilizes a still or camcorder to catch a scene, and after that to translate it into a tactile and acoustic format but because of the restricted spatial determination, we dont expect that we will have the capacity to show all the visual details. Foremost, the immediate interpretation of visual signs into acoustic and material signs is impossible in a natural way. In this manner, the visual to acoustic material interpretation should be founded on picture division into perceptually uniform locales and afterward mapping of each fragment into an unmistakable acoustic flag, such a representation will give key data about the area, shape, and personality of the key questions in the scene.

We present and test different arrangements for the acoustic material show of basic shapes and formats. In every setup, the touch screen is apportioned into districts, each with a specific sound field. Every area speaks to a protest, some portion of a question, foundation, or another component of a visual scene or graphical display. The sound-related input played back on stereo earphones, relies on upon the finger position on the touch screen. Not at all like the TTT, where the acoustic flag comprises of discourse that clarifies the material example (ordinarily a piece graph) investigated with the finger, we utilize sound for question distinguishing proof and for directing the finger to at least one items or along their boundary. For the last mentioned, we make utilization of spatial sound, as head-related exchange capacities (HRTFs) for rendering sound directionality and varieties of sound power or different properties for rendering vicinity.

The proposed approach s objective is to present to the client the object/scenery in acoustic material frame. One approach for doing this is by specifically making an interpretation of visual signs into touch and sound.

For instance, the tongue show we said above depends on the direct translation of picture powers caught by a camera into voltages.

Another illustration is "SoundView," created by Doelet , whereby the client effectively investigates a shading picture on a tablet with a pointer. The shade of every pixel is meant a sound, with the pointer acting like a gramophone needle making sounds as it "scratches" the picture surface.

Meijers imaging framework named "vOICe", maps a 64 × 64 picture with 16 dim levels to a grouping of tones. The vertical measurement of the picture is represented by recurrence and the even measurement is spoken to by time and stereo panning. The clamor of the tone is proportional to the brilliance of the relating pixel. In the framework proposed by Hernandez et al. sound beams exude from the questioned surface in an indistinguishable way from light beams. Among the immediate mappings, we ought to specify the version of grayscale qualities to material examples proposed by Barner et al. , utilizing computerized half toning. Notwithstanding, as we saw, coordinate mapping frameworks are not extremely viable on account of the restricted spatial determination of touch and hearing and the absence of natural mappings from the visual to the acoustic or material space.

Rather than the immediate mapping approaches, the proposed approach accepts that the picture has been broken down to get a semantic mapping, which then is displayed to the client in acoustic material shape. The client can effectively investigate the shape. Various frameworks have been proposed thusly, Su et al. tried an iPhone display with stereo panned acoustic criticism given by means of earphones to pass on line drawings. While, Cohen et al. proposed a tablet PC-based display, where the client utilizes a stylus and sound-related input (tones with differing pitch and clamor, discourse, and pre-recorded sounds) to see charts and social data. Jacobson executed a sound empowered guide in a touch cushion that plays back voice and normal sounds that relate to the finger position. Parenteet et al. built up a sound haptic guide utilizing 3-D spatial sounds, where the client investigates the guide with a mouse, console, or touch-screen, questioning data about the focuses went to. Thusly, "Wanderer", the "Talking Tactile Maps", and the TTT have given an embedded surface that the client filters with the finger, while a sound-related flag is played back at certain finger positions. A semantic approach which uses 3-D spatial sounds is the individual direction framework proposed by Loomis et al. , which decides the position, and utilizes a virtual acoustic show.

At long last, Ribeiro et al. proposed a framework that allies questions in a genuine scene utilizing spatialized three-dimensional sounds. The spatialized sound version was done utilizing HRTFs from the CIPIC database, power, and direct-to-reverberant proportion. Their approach is semantic in that PC vision methods are utilized to recognize objects in the scene. There is an immediate correlation between the two outcomes and is impractical due to the distinctive assignments in the two examinations.

The objective of this paper is to investigate the favorable circumstances and limitations of converting visual data, and specifically, providing object personality (material, shape) and position, and additionally general scene format, in an acoustic material frame. The purpose of additionally considering a static material overlay is to investigate the relative points of interest of the two modalities, in foresight to determine which gadgets will have the capacity to produce dynamic raised-dot designs. The current material stick exhibits are massive, costly, and cant be consolidated with touch screens. The key recognizing features of the proposed approach are the dynamic investigation of the object, the utilization of spatialized sounds however not really practical, mapping of articles and activities to sounds.

Our exploratory outcomes exhibit that the best setups for the impression of basic shapes with sound-related input give correctness in the upper 80% territory, fundamentally beating existing methodologies, similar to "Sound-see," , "vOICe" , and TeslaTouch. Be that as it may, the execution debases as the shapes turn out to be more convoluted. It is a time-consuming activity but we trust that both of these deficiencies can be alleviated by user preparation. At the point when a material input is included the type of raised-speck design overlays, shape observation can achieve 100% for more complex objects. We additionally demonstrate that the "virtual cane" configuration is very powerful in finding and recognizing the objects in a basic scene design.

## 2. ACOUSTIC-TACTILE DISPLAY

This section shows setups for an acoustic material introduction of basic shapes and designs. The touch screen typically reacts to the centroid of the range that is in contact with the fingertip.

In the proposed method of investigation, the user checks the 2-D shape or design sequentially, tuning into one sound source at any given moment, the one that relates to the area of the finger. Like in Braille the utilization of alternate fingers can be helpful for perusing when they are utilized for looking ahead. This, however, is not permitted in our present project, keeping in mind the end goal is to dodge any diversions while we research what can be accomplished with one sound at any given moment. Data that is serially introduced in our setup ought to appear differently in relation to vision, where there is a blend of consecutive high-determination, constrained view filtering by the fovea and low-determination information over a wide receptor field in the fringe. A huge bottleneck that occurs is the serial introduction in the view of raised-line drawings. Strikingly, Loomis et al. showed that the restrictions forced by point-by-point serial introduction are not innate to any one methodology. When they limited down the visual field of view to the measure of a fingertip and requested that members perceive line drawings, the recognition exactness was no superior to anything that accomplished in perceiving raised-line drawings with touch.

A key challenge is the measure of psychological exertion that the proposed framework requires for managing the checking finger to the question or along its limit, which may meddle with the intellectual exertion required for shape and design observation. To decrease the exertion, a portion of the arrangements we propose in this section depend on spatial sound prompts.

As we see, the haptic following of raised-spot designs requires pretty much no intellectual exertion, as does the following of straightforward raised-line drawings.

### 2.1 ACOUSTIC-TACTILE CONFIGURATIONS

The proposed application makes use of an Apple iPad. Nonetheless, any gadget consisting of touch screens can be put into practice. All the layouts make use of sound played through stereophonic headphones.
Model of object can be staged as line drawing or substantial shape. As finger scanning is the most effectively used method of analyzing, this method can be correlated to haptic recognition of erected line images.

#### 2.1.1 Configuration C1: Impersonating Figures using dual tone that are constant.

We split the display into two sectors, object and background. Each of these sectors is represented by a unique sound. The advantage served here is, the user is clearly able to recognize the inside and the background. The border is represented by the changeover in two sounds.

#### 2.1.2 Configuration C2: Impersonating Figures using dual tone that are constant.

We split the display into two sectors, object interior, object border, and background. Each of these sectors is represented by a unique sound. Observational investigation with C1 showed striving to track the borders. This was a confusing mechanism. Hence to eradicate this drawback, a unique sound is maintained around the outline.
Though, various deficiencies must be taken into account. There are probabilities of the finger to wander between the borders and enclosing portions while perceiving the border.

**2.1.3 Configuration C3: Representation of shape using Tremolo**

This method uses the inclusion of proximity feedback along the borders. This is done using the *Tremolo Signal*.

Here, the border is confined to be a thin line, with strips added on each sides. When a finger is positioned within the strip on the background, a clear implication is given while moving away. Else, the original tone is maintained.

**2.1.4 Configuration C4: Impersonating Figures using triple tones and loudness.**

This method endeavors to bind the most approving attributes of C2 AND C3. This can be achieved by making use of a unique tone for the border components. It also uses a unique tone for differentiating the triple tones. Hence the major ultimatum was to preserve the distinct tones facilitate a concrete, momentary, and automatic proximity cue inside the outlined border.

**2.1.5 Configuration C5: Illustration of shape using HRTF:**

- This method makes use of dimensional tones to detect objects and trace the outline. The main advantage served here is there is no necessity to motion the fingers in order to determine if the directionality is accurate.
- In addition to the specified configurations, the focus here is to instruct the fingers from anywhere on the screen. This is done using spatial sound.
- In C1, C2, and C4, the division of screen is done in three portions. When finger is placed inside an object, a constant tone is maintained. For segments relating to border and background, HRFT is used to provide directionality.
- HRTF is used to illustrate the diffraction by a users torso, ear, head and how it customizes the sound source. Sound localization can be perfected by striking and effective tapping.

**2.1.6 Configuration C6: Perception of scene using virtual cane**

Here, the main focus is to deliver an uncomplicated scene having many objects. Here we need to dispatch size, location, integrity, material content of each object. We narrow our focus towards the attributes and layout.

Shape rendering can be dealt with separately. A common example includes “Zoomed in mode”. To identify an object, each object can be mapped to an arbitrary sound.

For improving the given case, a characteristic rubbing can be a preferable option. In contrary to the situation, tapping is known to produce a relatively effective perceptible sound. This is inspired by the traditional “long cane” method.

Previous assumptions were related to objects being in a linear structure or being disarranged. More complicated objects can also be handled. Background can be muted while a distinct tapping sound can be given to each object. For further enhancement, the zoomed in mode can be put to practice.

**2.1.7 Perception of scene using Overlaid Tactile Imprint:**

- Here we test the combined perception of tactile and acoustic gestures by overlapping a raised-dot-pattern etched on paper on the touch screen.
- Advantage of tactile overlay is that perception of object is much simpler. Zoomed in mode does not necessarily have to be used. Material identification on the other hand is done using sound
- Various patterns of tactile can be used to identify objects. More the pattern, more

complexity is introduced to discriminate.

- However, since tactile overlay is static, this serves as a disadvantage. But fixed objects can be displayed using tactile patterns and moving objects can be displayed using sound.

## 3. EMPIRICAL STUDIES

For each of the 7 configurations given earlier, a sequence of empirical studies were carried out. Three distinctive shapes were used for the first five configurations, whereas a single layout was used for the rest.
Studies were carried out in two sets. Configurations C1-C3 were done in the first set and C5-C7. From the conclusion, C5 and C4 were modified.
Next, the second configuration study was carried out to compare the unaltered original.

### 3.1 Participants

The study did not contain experts as participants. They were not familiar with the study objective. They also came from varying scholarly backgrounds and had different experience related to using devices with touch.
The first set of research was done with 20 participants of age category 19-56 years.
Everyone reported normal hearing and vision, except two alone. One reported nystagmus (from birth) and other reported tinnitus for 20 years and both were treated.
The second set was done with 11 people of a different group. Their ages ranged from 22 to 5 years. All except one person reported normal hearing and vision. One reported a deficiency in the left ear and was not treated.

### 3.2Procedure

The studies were conducted in a silent area in order to keep away from interruption. Stereo headphones were given to the participants to contact with touch screen and listen to auditory feedback. Each of them used a single finger for scanning, but were allowed to swap between fingers to avoid discomfort.
Direct Visual contact by participants with the touch screen and scanning finger was blocked.
This was done because by watching a finger move, identification of shape can be done easily. A box was kept for the touch screen to be placed within, where the front was open in front to make it easy for the person to insert their hand in order to access the screen. Written instructions were provided to the participants. They were allotted a specific time to ask questions till they understood the instructions clearly. The participants were able to see the layout during training examples.
The main aim was to determine an unknown shape. No feedback was provided to the users till completion, and participants were asked about their remarks at this point.
For further accuracy, the participants were asked to draw their anticipated shape on a sheet and describe it. They were asked to provide explanation in case of ambiguity. There was no contour matching involved in the process.
Kinesthetic memory aids a person to trace the perceived shape through raised line depiction.

### 3.3 Equipment and Material

The main equipments used are:

1) *Touch Screen*

Implemented on iPad 1.Users were allowed to modify the volume of playback to a level of comfort.

All the files were stored previously in WAV form.

2) *Head Phones*

Around the ear stereo, Sennheiser HD595 was used.

3) *Tactile Patterns*

"VersaPoint DuoBraille Embosser" was used. This was done for embossment of tactile patterns. This was then overlapped on the screen for alignment with corresponding areas.

### 3.4 Sound Design

SONAR pings were used for studies regarding C1,C2 and C4. To represent objects, prerecorded tapping sounds were used. Synthesized chirp sounds were used for C2,C4 and C5. This was done to discriminate between background and object.

Monophonic sound was used for C1-C4. Constant tremolos were used for C3. HRTF was used for C5 and C6 for directional tones. Directional and stereophonic sounds were used for C5.

### 3.5 Other Experimental Details

*Configurations C1-C5*: Shape used for training here was a cross. Test shapes included equilateral triangle, square, circle presented one at a time. Apart from the cross, all the shaped had approximately the same area in terms of pixels of square. Randomly, each shape was presented in a random order. Though, the order was fixed. To enable tracing of edge, border strips were given. They however could use any method they wanted to identify shape.

*Configuration C6*: Pre tapped sounds were used in the zoomed out mode. Background was kept silent. Double tapping triggered the mode change and a short tone was used for its representation. During the start of the experiment, the virtual cane analogy was provided. Participants were not given any prior information about the sounds that were possible.

*Configuration C7*: The sound signals used here were the same as C6. However, a sheet with tactile patterns embossed was overlapped on the screen. Hence, the patterns were aligned. To take into account the errors in identification of material, the materials were confined. Hence participants were given a tapping sound labeled wood at the beginning.

## 4. EXPERIMENTAL RESULTS

TABLE I
SUMMARY OF CONFIGURATIONS

| | |
|---|---|
| C1 | 2 constant sounds |
| C2 | 3 constant sounds |
| C3 | 2 tremolo sounds with varying border rate |
| C4 | 3 sounds with varying border intensity |
| C5 | 3 Sounds with HRTF in border and background |
| C6 | Virtual cane-acoustic display with zoomed-in mode |
| C7 | Virtual cane-acoustic display with tactile overlay |

As discussed in Section III, we supervised the shape perception experiments in two sets In the first one, we tested Configurations C1-C3 and C5-C7.On the basis of the results, we then added C4, and conducted a second set of experiments with that, a modified C5, and

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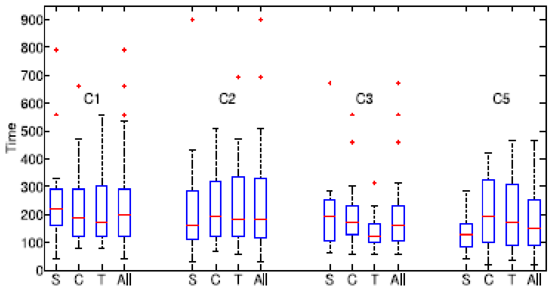
the unaltered C2.

The experiments conducted were very time consuming and were carried out with sighted, visually- blocked, unpaid volunteers. As a result, we could only conduct few trials for each configuration.

In the shape experiments, performance was measured by the accuracy of the participant, response and the time it took to complete the experiment. The rating of each response was binary (correct/incorrect), based on the verbal description and the drawing. Since the accuracy is a categorical variable (nominal data), we used the chi-square test of independence (TOI) and goodness of fit (GOF) for categorical analysis of the accuracies. The timing data, on the other hand, is continuous but, due to limited sample sizes, high variance, and outliers, a normal distribution cannot be safely assumed. Therefore, we resorted to a non-parametric method, the Kruskal-Wallis H test (KWHT) for the statistical analysis of the timing data.

### 4.1 Initial set of Experiments with shape composition

Table II shows results from the experiments C1, C2, C3 and C5. The table shows certainty and time averaged for all participants considering every configuration and shape. No compelling difference in accuracy was observed for the chi-square TOI. Though for the pair wise comparison involving chi-square GOF, C2 is comparatively more effective than C1.The same applies to C5. These collectively support the idea of adding a border strip with a unique sound. However, the difference between C1 and C3 is not powerful. This indicated that the method of using tremolo is not efficient.




The given figure shows box plots for the amount of time taken by participants to identify every shape for each configuration. It also shows them combined across various shapes. Box edges represent the twenty fifth and twenty seventh percentiles. Separate whisker is used to extend the box by 1.5 times its original length. The crosses depict the outliers. The paired comparisons between C1 and C5 and C1 and C3 proved that a shorter time was required for C5 and C3 compared to that of C1. Hence in terms of accuracy and timing,C5 was the only configuration preferred over C1. This can be associated with the inclusion on spatial sound in C5.

We have concluded that addition of a distinct border sound enhances the certainty and inclusion of spatial sound enhances timing. Experiments from participants however show the undependability of C3.

Out of all the four configurations, C5 was observed to receive the maximum positive feedback with an insistence on ease of use. The inclusion of directional sounds helped in tracing the edges and delivered cues regarding the orientation of edge. Though, there were reports regarding limited help in the background region.

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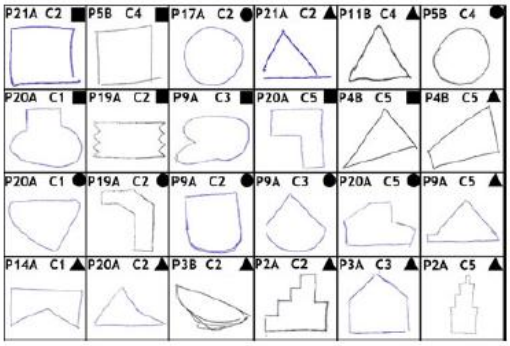
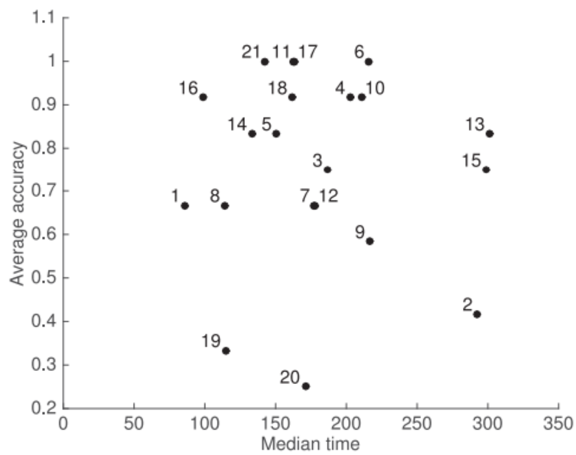
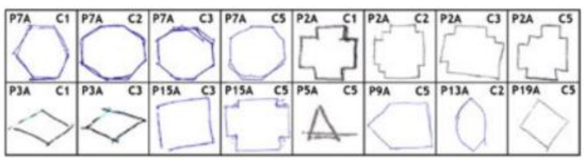



The above shows drawings made by participants from both sets of the shape experiments. Drawings on the first row show they were marked as correct. The rest were marked as wrong. It is clear that the participants had no prior knowledge considering the diversity of drawings.




The given graph shows the relationship between accuracy and time for every participant. As we can see, there were broad performance deviations. Approximately, a third of participants have an accuracy of 80% and median time of lesser than three minutes. Only 14% are observed to have a median time above 4 minutes and 3 have an accuracy of below 50%. The content in Table II also suggests accuracy is varied according to the shape. There was less accuracy in identifying circle compared to the other shapes. Hence it is normal to infer detecting curved edges is less accurate compared to the others.



The above figures were drawn by 6 different participants, and included pixel and line approximations. These are used as there is difficulty in tracing object boundaries.

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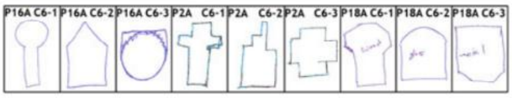
### 4.2. Experiments with the configurations of layout

The table given below provides a summary of results from experiments with C6 and C7.Participants had no issues in determining the number of objects, in both the cases. C6 showed significant errors in identification of material It was confined to disorientation between metal and glass. This was not easy to distinguish. Hence there is a need for more distinguishable sounds, even if it is not realistic.

In the zoomed in mode (C6), the accuracy was low compared to the simple shapes used to test C1 to C5. We also know that C5 is the same as the zoomed in mode. But, there is complication in the objects in the layout. This is a possible reason for limited performance. However, two participants reported perfect responses.

TABLE III
RESULTS OF EXPERIMENTS WITH C6 AND C7

| | Configuration C6 | | | Configuration C7 | | |
|---|---|---|---|---|---|---|
| Accuracy (%) | Obj. 1 | Obj. 2 | Obj. 3 | Obj. 1 | Obj. 2 | Obj. 3 |
| Number of Objects | | 100 | | | 100 | |
| Material Identification | 90 | 80 | 70 | 100 | 60 | 60 |
| Shape Identification | 20 | 30 | 20 | 100 | 100 | 100 |
| Shape (aver.) | | 23.3 | | | 100 | |
| Overall Median Time (s) | | 709 | | | 185.5 | |




The above figure shows sketches from the experiments with C6. The first row shows successful sketches while the second shows failed efforts to recognize shapes in the first row. Even these can be considered as pixel or linear approximations of the real shape. However, a curved line approximation of roof exists as well. The shapes drawn can be represented by "temporally extended exploration" using the finger. Fingers can also create haptic illusions. C7 performs better than C6,in terms of timing and accuracy, according to statistical analysis.

This is due to usage of raised dot patterns in a flat background. This is more useful for sound rendition and shape identification. Hence the time consumed for zoomed in mode is eliminated. When two or more distinct raised dot patterns are used to differentiate adjacent objects, the performance is cut down.

For interactive applications, tactile feedback is not suited as it is static. The emergence of dynamic tactile equipments can solve this issue. Another approach is to give feedback through using variable friction.

TABLE IV
SECOND SET OF EXPERIMENTS: PERFORMANCE OVER ALL 11 PARTICIPANTS (SQUARE, CIRCLE, TRIANGLE)

| | C2 | | | C4 | | | C5 | | |
|---|---|---|---|---|---|---|---|---|---|
| | SQ | CI | TR | SQ | CI | TR | SQ | CI | TR |
| Accuracy (%) | 100 | 45 | 64 | 100 | 64 | 82 | 91 | 64 | 64 |
| Aver. Accuracy | | 69.7 % | | | 81.8 % | | | 72.7 % | |
| Time (s) | 131 | 372 | 240 | 167 | 274 | 186 | 65 | 122 | 141 |
| Overall Time | | 202 s | | | 186 s | | | 109 s | |
| Difficulty (1-10) | | 6 | | | 6 | | | 3 | |

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### 4.3. Second Set of Experiments with Shape Compositions

Table IV outlines the outcome of the second set of experiments, operated with C2,C4 and modified C5.the below figure shows the time taken for the participants to identify the shapes with the configurations. In Section II we popularized C4 to provide a strong, spontaneous and inherent adjacency cue within the border. In Section III, we examined the modifications of sound design in C5.To compare the performance of two sets of participants, we included C2 in both experiments.

On comparison with Table II, we saw a 12.5% drop in accuracy and a 12% increase in time for C2 in the second set. The performance drop could be associated to the natural abilities of the participants or the experiences with touch screen devices. A closer look exposed that few owned and used touch screen devices, while the remaining had limited experience.

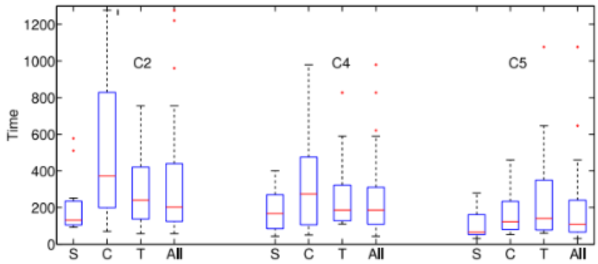


Table V outlines the result of the experiments for the experienced group of participants. Note that the total performance for C2 is comparable with both C4 and C5 in terms of accuracy and time. The modified C5 showed a 53% reduction for the experienced group. Our results showed that C5 was the fastest and easiest configuration and C4 is better than C2.Thus,the importance of exploiting instantaneous acoustic cues for shape analysis becomes apparent.

Further improvements can be obtained by using individually registered HRTFs, as well as finer angular quantization and interpolation. Such improvements are costly and time consuming, but may be beneficial, especially for BVI participants.

TABLE V
SECOND SET OF EXPERIMENTS: PERFORMANCE OVER 6 OF THE 11 PARTICIPANTS (SQUARE, CIRCLE, TRIANGLE)

| | C2 | | | C4 | | | C5 | | |
|---|---|---|---|---|---|---|---|---|---|
| | SQ | CI | TR | SQ | CI | TR | SQ | CI | TR |
| Accuracy (%) | 100 | 50 | 83.3 | 100 | 66.7 | 100 | 100 | 83.3 | 83.3 |
| Aver. Accuracy | | 77.8 % | | | 88.9 % | | | 88.9 % | |
| Time (s) | 121 | 200 | 166 | 126 | 111 | 129 | 57 | 96.5 | 82 |
| Overall Time | | 166 s | | | 121 s | | | 69 s | |
| Difficulty (1-10) | | 7.5 | | | 6 | | | 2.75 | |

### 4.4. Correlation with Existing Techniques

We first contrast our outcomes with those of Soundview, which was executed in a graphical tablet utilizing a device for scanning. Because of the distinctions in the setups, we cannot perform factual investigation for the comparison. Soundview utilized two sounds, one inside the object and one in the background, as in C1.However, the sound played to the member at a given time relied on both the location and the speed of the pointer. Three experiments were performed. The first one allowed participants to draw the shapes out of each trial. In the second one they chose the shapes they perceived from a set of 18 shapes. In the third, they had to pick one out of six possible shapes, each presented once. The overall accuracy of the three experiments were 30%,38% and 66% respectively. Each of the setups were given a time limit of about 90 seconds. We believe that the poor attainment of *Soundview* can be attributed to the dependency of acoustic stimuli on the velocity of the pointer, which makes it too complicated for participants to decode. In addition, they tested the performance of the *vOICe* system in their six-shape setup, and found that the overall accuracy was only 31.0%. Overall, our experimental setup was harder .

We additionally use the TeslaTouch experiments as they also attempted to convey simple shapes. There were no time limitations for the experiments. They reported just below 80% accuracy for the solid rendering, and just above 40% for the other two configurations. The average time per trial was less than two minutes. While their results for the solid configuration were about as good as those of our best configuration, one should keep in mind that the task of discriminating among three known shapes is a lot easier than that of identifying an unknown shape. The fact that the use of a third friction level for the object outline does not improve performance is also an indication that the finger is sensitive to changes in friction rather than absolute levels.

## 6. CONCLUSION

We have proposed another approach for conveying graphical and pictorial data through hearing and touch, and demonstrated that it can be connected to the view of essential geometric shapes, fundamentally outflanking existing methodologies. We have additionally demonstrated that our approach can be utilized to find and recognize the articles in a straightforward scene design, utilizing what we call a "virtual cane," an interface that plays back tapping sounds as the client investigates the scene on a touch screen with their finger.

Exact reviews with the BHI community and various acoustic-material arrangements exhibited the upsides of spatial sound (directionality and vicinity prompts) for element show of data, and that raised-dot designs give the best static shape version. Our reviews additionally demonstrate the restrictions of acoustic-material interfaces, to be specific that investigation is moderate and execution corrupts with design of complex and multifaceted nature.

Our experimental reviews were exceptionally tedious and were completed with unpaid volunteers, with next to no preparation. Along these lines, our exploratory information were constrained contrasted with what commonplace reviews deliver, and accordingly, some of our conclusions are not factually critical. Notwithstanding, by investigating a wide assortment of outline options and concentrating on various parts of the acoustic-material interfaces, our outcomes offer numerous important experiences for the plan of future efficient tests, utilizing the best designs, with paid (and in this way more dedicated) BHI members.

Looking forward, our outcomes show that we ought to consolidate the best of what each of the modalities can offer. As dynamic material gadgets get to be distinctly accessible, raised-dot examples can be utilized for shape acknowledgment, while sound can be utilized for route in the virtual space (giving directionality and nearness information) and object acknowledgment.

In future work, we additionally plan to investigate the utilization of various fingers apart from the index finger, which will build the perceptual field and in addition the utilization of different concurrent sounds to pass on information about neighboring or blocked articles. The interface can likewise be expanded with GPS, accelerometer, camera, and GIS empowered maps. The proposed approach is relied upon to significantly affect outline, imaging, and route. .

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