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# Information Delivery on Mobile Devices Using Contour Icon Sonification

Charlie Cullen
*Dublin Institute of Technology*, charlie.cullen@dmc.dit.ie

Eugene Coyle
*Dublin Institute of Technology*, Eugene.Coyle@dit.ie

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**Charlie Cullen[φ] and Eugene Coyle***

[φ]Digital Media Centre (DMC),
Dublin Institute of Technology
Dublin 2, Republic of Ireland
E-mail: [φ] charlie.cullen@dit.ie

* Control Systems and Electrical Engineering.
Dublin Institute of Technology
Dublin 2, Republic of Ireland
E-mail: *eugene.coyle@dit.ie

**This paper examines the use of musical patterns to convey information, specifically in the context of mobile devices. Existing mechanisms (such as the popularity of the Morse code SMS alert) suggest that the use of musical patterns on mobile devices can be a very efficient and powerful method of data delivery. Unique musical patterns based on templates known as Contour Icons are used to represent specific data variables, with the output rendering of these patterns being referred to as a Sonification of that data. Contour Icon patterns mimic basic shapes and structures, thus providing listeners with a means of categorising them in a high level manner. Potential Sonification applications involving mobile devices are already in testing, with the aim of delivering data to mobile users in a fast, efficient and hands-free manner. It is the goal of this research to provide greater functionality on mobile devices using Sonification.**

Keywords – Contour Icon **Sonification, Mobile Devices.**

## I INTRODUCTION

Sonification can be defined as the use of non-speech audio to convey information [1], and so has great potential for application on mobile devices. Mobile device technologies often struggle to deliver information content within the constraints of the hardware available, and many features available on mobile phones are workaround solutions due to the physical limitations of such small devices. One of the most powerful (and popular) aspects of mobile phones are ring tones, which can be configured by users to denote different callers or groups. This basic use of Sonification has developed as an ad-hoc solution to the requirement of caller identification in a fast, efficient and hands-free manner. It is argued that the potential of such ring tones to convey more specific data is huge, with many different forms of information content being applicable for direct sonification.

Mobile applications utilising audio have the distinct advantages of speed and efficiency over their associated visual counterparts. The far greater processing and storage overheads of visual mechanisms are also compounded by their requirement of user focus, often preventing other tasks or operations being performed. With the system presented in this paper, the element of focus is hands free in audio applications, allowing the user to effectively multitask in a variety of situations and environments.

## II AUDIO COGNITION

### a) Neural processing of audio

Audio is an often overlooked, yet very powerful means of information delivery. The faster processing rate of audio over haptic and visual stimuli (2ms [2] for audio, compared to 10ms for haptic and 100ms for visual information), suggests that the human auditory cortex may have great potential as a conduit of information. The innate audio capability of all humans (and indeed most animals [3]) is amply demonstrated by the ability of infants to discriminate between pitches [4], melodic contour [5] and rhythm [6] as well as an adult can.

This ability even extends to the segmenting of melodies [7] into smaller phrases, and the association of music with other events [8] in a similar manner to adults. The mechanism for such processing is musically specific, with certain neurons directly responsible for pitch perception, rhythm and melodic contour [9] and [10] being found only in the right hemisphere of the brain [11].

### b) *Melodic Contour*

Melodic contour has been considered by many musicologists as a means of defining relative changes in pitch [12] with respect to time, rather than the definition of absolute pitch values. In this manner, the shape, direction and range of a melody can all be summarised by its overall contour. Contour can be considered an important part of musical memory. Dowling [13] suggests that contour information functions separately and independently from scalar information in memory. Experiments by Edworthy [14] showed that single pitch alterations in a melody could be detected by subjects as changes in contour- even when they were unable to define what pitch had been actually altered in the pattern.

This capability is believed to be present in infancy [15] (around 5 months), at a stage of development where changes in pitch cannot be recognised. It has even been shown that different brain cells are used in the processing of melodic contour [16] than are used in the detection of temporal or harmonic [17] components of music. This aspect of neural activity would again suggest that different parts of the brain are used [18] in the detection and recognition of musical events: rhythmic factors being paramount in detection, while melodic contour and range [19] and [20] being more important in the recognition of familiar and recently learned melodies. Although rhythmic factors (alongside pitch and timbre) are vital to the detection of an individual pattern, it could conceivably aid subsequent recognition if factors used by long-term memory were also employed.

### c) *Existing Sonification mechanisms*

Sonification is best considered as a new definition for an existing principle, with many common examples being found in everyday life. Any form of audio alarm or siren is instantly recognisable as being specific to a particular type of alert, either as a static event that may signal a fire or theft, or as a mobile broadcast signifying the presence of an ambulance or fire engine.

In situations such as this the Sonification of the information required (that there is a problem concerning some aspect of the home or vehicle) has not been considered to a degree where it performs its correct function, and thus largely ceases to function in the correct manner at all. Many alarm manufacturers are becoming increasingly more aware of the pitfalls and benefits of Sonification systems, and are consequently striving to develop better means [21] of delivering warning and alert information as accurately as possible.

Mobile phones perform Sonification on a regular basis, with the common practice of assigning different ring tones to different groups of callers being a prime example. In this instance, the ring tone is used to convey specific information about the incoming call and so is a Sonification of caller identification data. Similarly, whenever the standard SMS alert tone is heard in a public place, many mobile phone users will instinctively check their phone for a message. The popularity of the SMS alert tone pattern serves to highlight the potential of musical patterns constructed using more comprehensive methods.

## III CONTOUR ICON PATTERN DESIGN

Bregman [22] suggests that visual representations of audio are of great benefit in description and analysis, with many of the Gestalt [22] laws of grouping by proximity being equally applicable to both visual and audio events. In view of this, a contour based design and representation method was embarked upon. In considering the possibilities of a set of icons used to represent musical patterns, it was decided that simple shapes describing melodic events would be used as the design template for those patterns. Contour based representations of musical patterns were used by the likes of Schoneberg [23] and Toch [24] as a means of conveying more verbose information about a musical score. The use of contour as a graphical means of description was taken further by ethnomusicologist Charles Adams [25], who used contour as the principle classification in his study of Native American melodies.

Adams suggests that a contour can be defined in terms of 4 minimal boundary pitches: initial pitch (I), highest pitch (H), lowest pitch (L) and final pitch (F). These four boundary pitches form the basis of the Contour Icon design template. The boundary pitches allow the shape of the melody to be accurately specified from point to point- a useful framework for contour design. This use of boundary pitches also suggested benefits when seeking to create a set of patterns as individual from each other as possible. Users can often struggle to define patterns that begin or end on the same pitch. Because of this, the boundary pitches are used to ensure that each pattern differs in initial and final pitch from its counterparts- alongside its own unique melodic contour.

Contour Icons are constructed using standard flowchart shapes (Figure 1), with each shape ideally dictating the final melodic shape of the pattern. These shapes are also referred to by descriptive names intended to suggest the contour they represent, rather than by numerical methods.

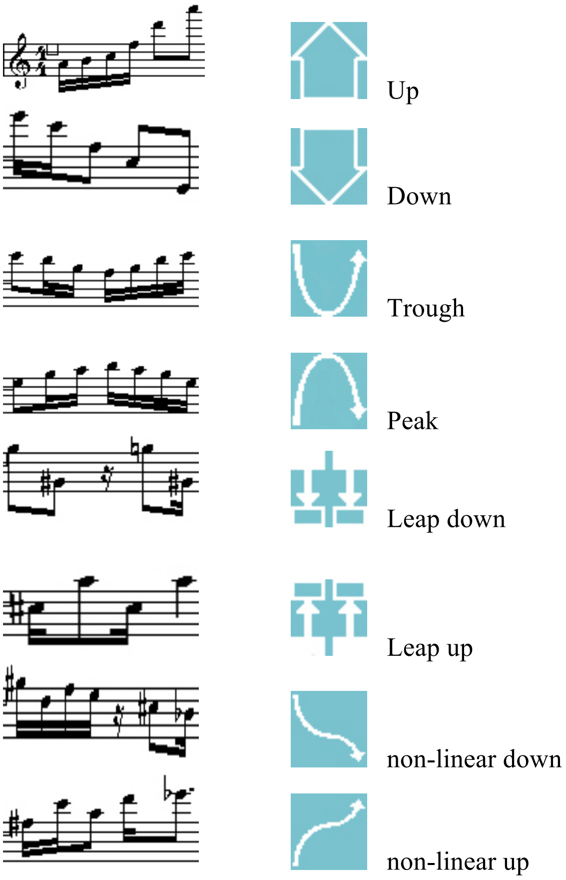


Figure 1. Contour Icon Pattern Set

The initial (I), final (F), high (H) and low (L) pitches are specified on an individual basis (Table 1). This arrangement is a useful means of specifying the uniqueness of each pattern.

| Contour Pattern | Initial (I) | Final (F) | High (H) | Low (L) |
|---|---|---|---|---|
| Up | A4 | A6 | A6 | A4 |
| Down | E6 | E4 | E6 | E4 |
| Trough | C6 | C6 | C6 | F5 |
| Peak | E5 | E5 | B5 | E5 |
| Leap down | G5 | G#4 | G5 | G#4 |
| Leap up | C#5 | A5 | A5 | C#5 |
| non-l down | G#5 | Bb4 | G#5 | Bb4 |
| non-l up | F#5 | Eb6 | Eb6 | F#5 |

Table 1. Boundary Pitch Table for Contour Icon Pattern Set

Tests performed on the comprehension rates of these patterns [26] suggest that there is great potential in high level design frameworks such as Contour Icons. By providing the user with a quick and intuitive means of detecting and remembering musical patterns, the Contour Icon designs lend themselves well to applications requiring fast and efficient information delivery. It is suggested that mobile device applications are a good candidate for such development, allowing such designs to be evaluated by large test groups.

## IV MOBILE DEVICE SONIFICATION

Development undertaken in conjunction with industrial partners seeks to implement Contour Icon Sonification methods on mobile devices using the MobilSon (Figure 2) application.


Figure 2. MobilSon front screen

This application is intended to be as simple as possible, in order that it can be used as quickly and efficiently as possible. A test application was first constructed using a Java emulator, and then delivered to a test handset for live evaluation.

The application is required to perform two main functions: (1)render Contour Icon MIDI [27] files in response to input SMS message and (2)provide means of previewing the ringtones concerned for training purposes. The design of the application concerns both the user interface (UI) and the data processing required. Each was developed separately, allowing the most efficient method to be ascertained for both.

### *a) User Interface*

The UI is required to be as straightforward to operate as possible. User input is focused on launching the application and previewing ringtones in the most efficient manner possible.

The user is given 2 choices- preview ringtones or run application. By previewing a ringtone the user can listen to both Boolean patterns for a given set, in order that they can familiarise themselves with them. When the main application is running, an SMS sent to the device will trigger the relevant ringtone. This allows the full functionality of the application to be assessed by users as required.

The operation of the UI (Figure 3) is determined as follows:

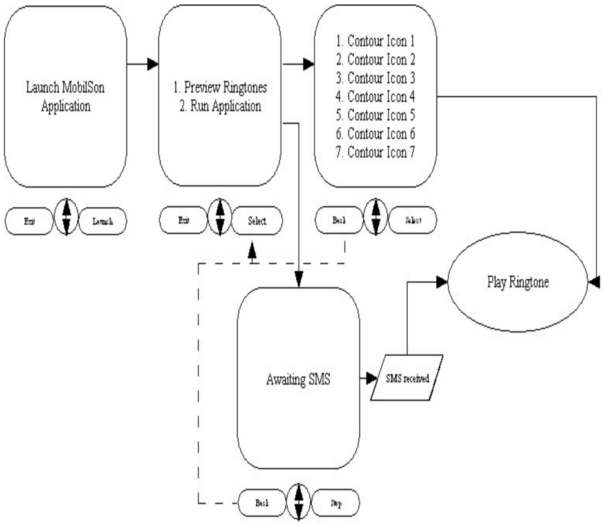


Figure 3: MobilSon Application User Interface Diagram

This design allows the user quick and easy access to the application, so that efficient operation may take place. It is desired that all users become as familiar with Contour Icons in as short a time as possible, and so a straightforward application is essential.

*b) Data Processing*

The java mobile media classes provide for an audioPlayer object, which can be controlled using standard commands such as play, pause and stop. The audioPlayer object can be loaded with the required media (of various types), and thus that media can be controlled by the user (or the application as required).

The application is required to render a Contour Icon MIDI file in response to an SMS message sent from another device (in simulation of live transmission from a server). The application is also required to render a Contour Icon MIDI file in response to a user request (preview). In rendering all files, the application is required to construct the relevant audioPlayer object and bind MIDI file information to it.

Once an audioPlayer object is constructed (Figure 4), it must be controlled and closed before exit. The functionality of the application requires each file to be played a maximum of 3 times, with the option of user intervention to terminate playback also being included.

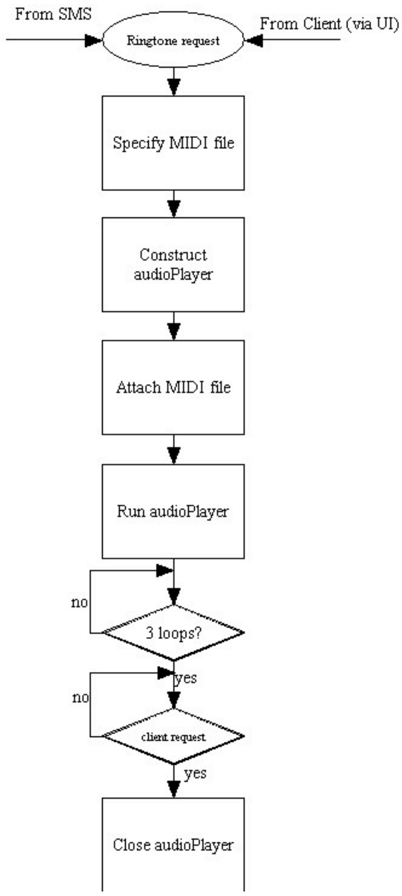


Figure 4: MobilSon Data Processing Flow Diagram

By implementing the data processing in this manner, the UI can be amended without affecting the basic functionality of the application itself. This allows the application to be tested using standard emulation packages bundled with the Java mobility software, before full UI testing using a live handset.

## V FUTURE WORK

Current development work is focussed on the testing of Contour Icon Sonification on Mobile Devices. It is believed that by using an interface such as MobilSon many of the existing principles of Sonification can be introduced to a much wider user base than the one presently aware of the technique. The potential for audio as a means of information delivery is enormous, particularly in situations where visual methods are either saturated or even inapplicable.

The means of providing additional levels of information content to end users is of great commercial benefit to many industries, not least those concerned with mobile devices. It is the aim of this research to provide potential solutions to this problem, in an effort to stimulate greater awareness and interest in the field.

## VI ACKNOWLEDGMENTS

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