Hear Her Fear: Data Sonification for Sensitizing Society on Crime Against Women in India

Surabhi S. Nath
Computer Science and Engineering
IIIT Delhi
New Delhi, India
surabhi16271@iiitd.ac.in

ABSTRACT
Data sonification is a means of representing data through sound and has been utilized in a variety of applications. Crime against women has been a rising concern in India. We explore the potential of data sonification to provide an immersive engagement with sensitive data on crime against women in Indian states. The data for nine crime categories covering thirty-five Indian states over a period of twelve years is acquired from National records. Sonification techniques of parameter mapping and auditory icons are adopted: sound parameters such as frequencies, amplitudes and timbres are incorporated to represent the crime data, and audio sounds of women screams are employed as auditory icons to emphasize the traumatic experience. Higher crime rates are assigned higher frequencies, harsher scream textures and larger amplitudes. A user-friendly interface is developed with multiple options for sequential and comparative data sonification. Through the interface, a user can evaluate and compare the extent of crime against women in different states, years or crime categories. Sound spatialization is used to immerse the listener in the sound and further intensify the sonification experience. To assess and validate effectiveness, a user study on twenty participants is conducted with feedback obtained through questionnaires. The responses indicate that the participants could comprehend trends in the data easily and found the data sonification experience impactful. Sonification may therefore prove to be a valuable tool for data representation in fields related to social and human studies.

CCS CONCEPTS
• Human-centered computing → User interface toolkits; Accessibility systems and tools.

KEYWORDS
Data sonification, Parameter mapping, Auditory icons, Sound spatialization, Crime against women, User interface, User study

1 INTRODUCTION
Research today demands appropriate and efficient techniques of data presentation for effective communication. Sonification is a versatile means of using sound for representing data. Sound can prove to be an impactful medium to represent data through its numerous parameters such as frequency, amplitude, timbre that can be adaptively controlled [20]. Sound, with its multi-dimensional nature, can be extremely powerful as it has the potential to capture features that may be missed out in a visual representation. Moreover, dynamic data are better understood through sound as its temporal nature can enable meaningful expression. In combination with visuals, sonification is an effective form of data portrayal as it has complementary properties which can enhance visual presentation [7]. Further, this medium improves accessibility by reaching out to the visually impaired population [1].

Data sonification has been applied in a variety of fields including medicine, finance, climatology and music composition [3, 8, 10, 11]. Besides the wide spectrum of use-cases, a few studies apply sonification to address social concerns. Lenzi et al. in their review article discuss five different projects applying sonification to socially relevant issues and compare them based on intentionality in their design [13]. Emotional regulation has been attempted in a study through sonification of physiological data of automobile drivers to increase self-awareness and ensure road safety [12]. Sonification has also been used to communicate data on alcohol health risks [19]. Furfaro et al. used interactive sonification to measure emotional, perceptual and motor behaviour of individuals [4]. Work by Oh et al. used biometric data to extract the degree of sleep and heart rate, which was sonified and displayed as 3D animation for diagnosing sleep disorders [15]. Furthermore, Buckley presented a new way of sensitizing students on risks regarding loan debts through musical scores [2]. Our study deals with another of today’s growing societal concerns in the Indian context – crime against women.

Crime against women is seen as an issue of public health and violation of human rights worldwide [17]. It is viewed as a serious setback to a country’s progress and prevails across income and education levels globally. In India, despite some efforts to secure women’s human rights, the situation continues to be abysmal and challenging [18]. Data on crime against women in India is published
by the National Crime Records Bureau (NCRB)\(^1\), Government of India. As per the statistics, the total number of crimes against women all India has increased by 70% from 2001 to 2012. In some states like Assam, Bihar, Jharkhand, Delhi, Odisha, and many North-Eastern States, the number of crimes has more than doubled, with an almost five times increase in West Bengal in the same period. More recently, the MeToo Movement in India has gained momentum with women openly voicing the harassment they face [16]. To call attention to this situation, the International Centre for Research on Women proposes to use media in creative ways to encourage introspection on the social attitudes and problems of crime against women in the society [9].

The aim of our study is to explore the potential of data sonification for communicating the rising crime rates in Indian states effectively and sensitizing society on this pressing issue. We have developed a user-friendly sonification interface which enables comparison of the scenarios in various states, crime categories and years, and identifies the critical cases demanding urgent attention. We have tested the efficacy of the designed interface by conducting a preliminary user-study that also employs sound spatialization. To the best of our knowledge, this is the first work on crime against women using data sonification.

2 DATA

2.1 Source

Data on the number of crime cases against women for 35 Indian states (including Union Territories) and All India, over 12 years from 2001 to 2012 on 9 crime categories, including total crimes were obtained from records published by NCRB in the Open Government Data Platform India, under public domain\(^2\). The data fields comprised of State \([1...36]\), Crime Category \([1...9]\) and Year \([2001...2012]\), resulting in a total data size of 36 x 9 x 12. Data for years subsequent to 2012 were not available. The nine crime categories comprise of Rape, Kidnapping & Abduction, Dowry Deaths, Assault on Women with Intent to Outrage her Modesty, Insult to the Modesty, Cruelty by Husband or Relatives, Immoral Traffic, Indecent Representation of Women and Total Crimes Against Women.

2.2 Processing

The available data recorded the absolute number of crime cases under the various heads. To enable meaningful interpretation of the number of crimes, we incorporated the population change over the years. Due to lack of the population data of each year, the decadal percent population growth (2001-2011) in all states published by the Census of India was used\(^3\). The population change across the twelve years was assumed to be uniform. The yearly number of crime cases was proportionately altered to accommodate for this change in each year (Algorithm 1). Further, the crime data was normalized by subtracting the value in the base year 2001 from the value in each year, which shifted the distribution to a starting value of 0 in 2001 (Algorithm 2).

\[\text{Algorithm 1: Incorporate Population}\]
\[\text{Input: Set of states } I \text{ and set of crime categories } J\]
\[\text{1 For a state } i \in I, \text{ the decadal percent population growth } = x_i\]
\[\text{2 Annual percent population growths in 2002, 2003, } \ldots, 2011, 2012 \text{ are taken to be } 0.1x_i, 0.2x_i, \ldots, x_i, 1.1x_i\]
\[\text{3 The number of crime cases for state } i \text{ in each crime category } j \in J \text{ is hence reduced by } 0.1x_i\% , 0.2x_i\% , \ldots, x_i\% , 1.1x_i\% \text{ to get the population incorporated number of crime cases}\]
\[\text{4 This is repeated for all states in } I\]

\[\text{Algorithm 2: Data Normalization}\]
\[\text{Input: Set of states } I, \text{ set of crime categories } J \text{ and set of years } K\]
\[\text{1 For a state } i \in I, \text{ crime category } j \in J, \text{ number of cases in every year } x_k \text{ (} k \text{ } \in K\text{) with first element } x_{2001} = y \text{ is normalized as } x_k = x_k - y\]
\[\text{2 This is repeated for all states in } I \text{ and crime categories in } J\]

3 SONIFICATION INTERFACE

3.1 Design

We have used the techniques of Parameter Mapping and Auditory Icons for data sonification.

1. Parameter mapping: It is the method of conversion of data values to sound parameters. It is a useful technique for conveying data of multi-dimensional nature. In our study, we have primarily experimented with frequencies, amplitudes and timbres since they best describe the sound and are the easiest to perceive. Synths, or sound generating units are developed to produce sound, and the parameter values are fed from the data in real-time [6].

2. Auditory Icons: These are self-explanatory real-life sounds, representative of the physical event being sonified. With a semantic content, they enable easy association and add to the emotional perception of the event [5]. We have acquired women screaming sound effects from YouTube to serve as auditory icons since they are the most natural sounds to characterize the pain and misery of the victims subjected to such crimes. Six freely available unique scream sounds are used with increasing harshness in timbre. These sounds were modified using pitch shifts or amplitude factors to map higher instances of crime with higher frequencies, larger amplitudes, harsher timbres, and vice versa.

The computer interface is developed using Supercollider [14], a free and open-source programming environment used for audio synthesis and algorithmic composition (Figure 1). Supercollider employs a Client-Server architecture and has flexible GUI systems to allow user interaction. The code is made available on GitHub\(^4\).

---

\(^1\)ncrb.gov.in/en/crime-india
\(^2\)data.gov.in/resources/crime-against-women-during-2001-2012
\(^3\)censusindia.gov.in/2011-prov-results/datafiles/india
\(^4\)github/surabhisnath/Data-Sonification-Crime-Against-Women-in-Indian-States
CRIME AGAINST WOMEN IN INDIAN STATES

Crime against women in India is a growing concern of today. It is hence very important to generate awareness on this pressing issue, especially among the youth. Explore the interface to perform sonification.

Choose type of sonification to perform

- Sequence through years for a particular state and crime
- Compare two crimes for a particular year and state
- Compare two states for a particular year and crime
- Compare two years for a particular state and crime

(a)

Select any state and crime. Sequence over the data for twelve years discretely and map it to either frequency or amplitude.

Choose state

Karnataka

Choose crime

RAPE

Select parameter to control

Frequency

Play

(b)

Choose any crime and year. Pick two states and compare the level of crime for the 2 cases.

Choose crime

DOWRY DEATH

Choose year

2012

Choose state 1

Madhya Pradesh

Choose state 2

Maharashtra

Play

(c)

Figure 1: Sonification Interface
3.2 Output
The graphical user interface (GUI) opens with a brief introduction to the study and a dropdown to select from four sonification options (Figure 1a).

The four options are grouped under two heads – Sequential Data Sonification and Comparative Data Sonification for the purpose of discussion. Every option leads to a new page with instructions for performing the sonification. The GUI provides the sonified output through the “Play” button, and allows switching between pages using the “Back” buttons on each page.

Sequential Data Sonification (Figure 1b): Performs sonification of data across the years for a particular state and crime. The user chooses a state and crime category. The crime data values across the twelve years are sonified as screams and played in succession as twelve distinct sounds. The length of each scream is around 1 second. The user has the choice to sonify the crime data as frequencies or as amplitudes. As frequencies, five scream timbres in increasing pitch are selected each mapped to a particular data range. For a higher value of crime data, the scream timbre is harsher and at a higher pitch. As amplitudes, the same baseline frequency scream sound is played in varying loudness based on the crime data values of the twelve years. Higher data values are louder. In both cases, when the twelve sounds are played, the participant can identify the patterns in the data by listening to the variations in the pitch/loudness and timbre of scream sounds. A visual graph is displayed along with the sonified output as feedback for comparison and validation that the data sonification is meaningful.

Comparative Data Sonification (Figure 1c): Performs sonification for comparing two crimes for a particular year and state, or for comparing two states for a particular year and crime, or for comparing two years for a particular state and crime. The user can fix any two variables out of state, crime category and year, and select two cases of the third variable for comparison. A single scream sound, sonified based on both frequency and amplitude are played along with the visuals displaying values indicating the number of crimes for the two cases. The scream for the larger data value is louder and at higher pitch. The participant can compare the crime situations in the two cases by differentiating between the two screams.

4 USER STUDY
4.1 Design
For testing the outcome and evaluating the impact of sonification for the data on crime against women in our study, a user survey was designed for participants to interact with the sonification interface, generate corresponding sonified audio outputs, and interpret the data. User responses were collected through a questionnaire and the effectiveness of sonification was analyzed. The survey was conducted in a Sound Spatialization Lab equipped with 8 speakers for multichannel audio output (Figure 2). A two-channel audio output can also be utilized for the study, however this setup was chosen for inducing a more immersive sonic experience.

Twenty participants, a mix of 13 male and 7 female candidates, 19 to 24 years of age, with homogeneous backgrounds, from undergraduate and graduate engineering programs volunteered for the survey. The survey was in accordance with the applicable institute policies. The participants were briefed on the purpose of the study prior to administration. The study was conducted individually for every participant in the lab and was approximately 10 minutes in duration. The door was closed and fans were switched off to prevent other external sound interference. Participants were instructed to test each of the four options available on the interface at least once. They could choose the type of crime, state and year of their interest and could modify the sonification parameters and produce sound output. The participants were undisturbed throughout the session. Soon after, they answered the questionnaire and gave their feedback.

The questionnaire consisted of 12 questions5. 4 questions were of multiple-choice type with provision for single option selection. The other 8 questions had a linear rating scale of 1 to 5, with 5 as the most favourable rating. In our analysis, we have considered participant response rating of 4 or 5 to be favourable outcomes.

4.2 Findings
The findings from the participant responses to the questionnaire (Figure 3) reveal that data sonification can be an effective medium for representing data of crime against women in Indian states. 85% of the respondents concurred that the representation was meaningful and that they could understand the varying trends in the data (Figure 3a). While 65% of the respondents thought that the crime rates in states had increased on average, 30% said they oscillated across states, crimes or years, and about 5% thought they decreased with time (Figure 3b). The corresponding underlying data also shows increase, oscillation and reduction in a similar proportion. As sound can easily capture the temporal nature of the data, it may have been easy for respondents to decipher the changing trend in the sonified twelve-year crime data.

On questions relating to comparing two states, crime categories or years with respect to any one parameter, nearly 95% of the respondents agreed that they found comparison evident. This demonstrates that the sonification performed was reasonable and difference between the two single screams was easy to comprehend. All the respondents agreed that the crime against women was a pressing issue (Figure 3c) and 90% reported that the data sonification
was highly impactful (Figure 3c). On comparing sound with visual representation, while 50% respondents thought that the experience was more impactful, 40% were somewhat unsure and 10% thought otherwise (Figure 3d). Considering that audio representation is an infrequently used technique and not as mainstream as visuals, the response distribution is still very encouraging. The interface was seen to be easy and self-explanatory by most respondents. Use of sound for data representation in general was supported by about half the number of participants, while the other half were mostly unsure (Figure 3f). This is also understandable given that not all data can be semantically represented through sound.

5 LIMITATIONS
Although the findings of this study are promising, the work has multiple limitations which would be addressed in future extensions. This preliminary user study is based on a small participant set and hence making definitive conclusions is difficult. The interface design is very basic and has the scope for introducing more features such as pause functionalities, time monitoring, process tracing and additional sound parameters such as tempos, distortions or reverbs to enhance the value of this study. Moreover, open-ended questions or interviews were not included which could add greater understanding of user-interface interaction. Further, ethical concerns such as long-term impact of the sonification experience on the users, particularly on victims or culprits are not addressed. Future
experiments could also compare the user experience with and without accompanying visual data display, and evaluate the impact of varied sound spatialization effects.

6 CONCLUSION

The work establishes sound as an effective medium to represent socially relevant data. It demonstrates the potential of data sonification as an immersive user experience to effectively bring out the severity of crime against women in Indian states. It is hoped that these innovations in the presentation of data will make a strong appeal and draw the attention of society to hear her fear.

ACKNOWLEDGMENTS

The author thanks Prof. Timothy Moyers for his guidance and support, Prof. Grace Eden for her helpful suggestions and IIIT Delhi for providing access to the Sound Spatialization Lab for undertaking this work.

REFERENCES

[1] Safinah Ali, Laya Muralidharan, Felicia Aliferi, Monali Agrawal, and Jacob Jorgensen. 2019. Sonify: Making Visual Graphs Accessible. In International Conference on Human Interaction and Emerging Technologies. Springer, 454–459.
[2] Zach Buckley. 2019. Tackling the Issue of Student Debt Through Data Sonification and Musical Scores. Proceedings of EVA London 2019 (2019), 127–132.
[3] Paolo Dell’Aversana, Gianluca Gabriellini, and Alfonso Amendola. 2016. Sonification of geophysical data through time–frequency analysis: theory and applications. Geophysical Prospecting 65, 1 (2016), 146–157.
[4] Enrico Furfaro, Frederic Bevilacqua, Nadia Berthouze, and Ana Tajadura-Jimenez. 2015. Sonification of virtual and real surface tapping: evaluation of behavior changes, surface perception and emotional indices. IEEE MultiMedia (2015).
[5] William W Gaver. 1986. Auditory icons: Using sound in computer interfaces. Human-computer interaction 2, 2 (1986), 167–177.
[6] Florian Grond and Jonathan Berger. 2011. Parameter mapping sonification. In The sonification handbook.
[7] Thomas Hermann, Andy Hunt, and John G Neuhoff. 2011. The sonification handbook. Logos Verlag Berlin.
[8] Tobias Hildebrandt, Simone Krügstein, and Stefanie Rinderle-Ma. 2012. On Applying Sonification Methods to Convey Business Process Data. In CASE Forum. Citeseer, 74–81.
[9] ICRW. 2004. Violence against women in India: A review of trends, patterns and responses.
[10] Jakob Nikolai Kather, Thomas Hermann, Yannick Buchschat, Tilmann Kramer, Lothar R Schad, and Frank Gerrit Zöllner. 2017. Polyphonic sonification of electrocardiography signals for diagnosis of cardiac pathologies. Scientific reports 7, 1 (2017), 1–6.
[11] Gregory Kramer, Bruce Walker, Terri Bonebright, Perry Cook, John H Flowers, Nadine Miner, and John Neuhoff. 2010. Sonification report: Status of the field and research agenda. (2010).
[12] Steven Landry, Myounghoon Jeon, Maryam FakhriHoseini, and David Tascarella. 2016. Listen to your drive: An in-vehicle sonification prototyping tool for driver state and performance data. In Adjunct Proceedings of the 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications. 21–26.
[13] Sara Lenzi and Paolo Ciuccarelli. 2020. Intentionality and design in the data sonification of social issues. Big Data & Society 7, 2 (2020), 2053951720944603.
[14] James McCarthy. 2002. Rethinking the computer music language: SuperCollider. Computer Music Journal 26, 4 (2002), 61–68.
[15] Na Yea Oh, Hee Soo Kim, and Jin Wan Park. 2018. Audiovisual Expression of Biometric Data Based on the Polysomnography Test. TECHART: Journal of Arts and Imaging Science 5, 4 (2018), 1–5.
[16] Sanjana Pegu. 2019. MeToo in India: building revolutions from solidarities. Decision 46, 2 (2019), 151–168.
[17] Nancy Felipe Russo. 2019. 12 Violence against women: A global health issue. In Progress in Psychological Science Around the World. Volume 2: Social and Applied Issues: Proceedings of the 28th International Congress of Psychology. Routledge.
[18] Arvind Verma, Hanif Qureshi, and Jee Yeern Kim. 2017. Exploring the trend of violence against women in India. International journal of comparative and applied criminal justice 41, 1-2 (2017), 3–18.
[19] Bartlomiej P Walus, Sandra Pauletto, and Amanda Mason-Jones. 2016. Sonification and music as support to the communication of alcohol-related health risks to young people. Journal on Multimodal User Interfaces 10, 3 (2016), 235–246.
[20] David Worrall. 2019. Intelligible sonifications. In Sonification Design. Springer, 105–150.