Concept Paper

A NOVEL INTERVENTION FOR DOMESTIC VIOLENCE PERCEPTION

Tanmay Debnath ^{1,†,✉}

¹ Student, IIIT Jabalpur; imtanmaydebnath@gmail.com

† Current address: Jabalpur, Madhya Pradesh, India

Version December 4, 2020 submitted to *Inventions*

Abstract: This paper poses a concept for the modulation of a novel intervention method that might potentially address the problem of domestic violence all around the world. This paper postulates the technical version of the module device and would adhere to the state-of-the-art interpretation of the technology stacked. Using audio perceptive software modules and scientific calculations related to the extraction of various features, including MFCCs and frequency analysis, a deep learning interpretation has been devised out and would be put into effect soon. The device is theorized to function in all environment scenarios, provided a threshold barrier that might be solved using manipulation in the control panel of the device. This paper has been framed in order where: (1) Design Workflow: A discussion has been provided regarding the designing of the device and the workflow. (2) Modules: a description of all the software modules used to build the prototype. (3) Components: Description of all the hardware modules used in the system. (4) System Workflow: Description of the physical model and visualization of the total schematic form of the model and its underlying connections.

Keywords: speech analysis; product design; domestic violence; product development

1. Introduction

The prevalence of domestic violence in today's world is nothing someone is unaware of. There have been several reports regarding women expressing themselves to have been a victim of this crime. According to W.H.O., about 35-percent of women have experienced some form of domestic violence and abuse worldwide [1,2]. Psychology and human rights departments classify the violence into several terms and many of them are quite frequent in families [3]. Here, we would be considering some of the most prevalent instances of domestic violence - Verbal and Physical abuse. These two factors have been identified as some of the most prevalent outcomes in a domestic violence case and several witnesses and case files are stating and confirming it. Upon an intensified literature review, it has been found that there has not been any important inventions and interventions designed to address this form of societal depression.

This paper presents a novel intervention and invention that would address the form of violence by detecting the vibrations in the home environment and analyzing the sound threshold that is set to inform the higher authorities and other helping aids for the victim. In concise form, the device uses a python-built module for the interaction with the hardware modules. The device forms in the boundary of Engineering, Social Science, Psychology, and Human Rights. Hence, for the implementation of the same, a huge team of researchers and enthusiasts would be required that would make the device from the prototype model to proper implementation mode. To the best of my knowledge, this form of device is one of a kind and is expected to instigate research for societal pressures and depressions.

2. Domestic Violence: Overview around the world

Instances of domestic violence are quite large and including all the instances here is way beyond the scope of this research paper. Here, a brief overview of the domestic violence situation has been presented from all around the world. Alberta, Canada has compiled some of the data regarding domestic violence activities and categorized them according to their severity. Some lead to criminal activity, some do not and some even don't reach up to the authorities. If properly claimed, then the total rate of the increase in the cases of domestic violence might increase exponentially.

Figure 1. An overview of instances of domestic violence recorded during the tenure of 2009-2019. The data has been categorized as criminal and non-criminal activities by the Canadian Government.

From the above figure, it is quite clear that there have been fluctuations in the overall crime rate concerning domestic violence. In the previous year, there has been a decline noticed regarding the reporting of domestic violence allegations. Both in the context of criminal and non-criminal activities. A much clearer view can be obtained when we would observe the overall trend.

Figure 2. The general trend of the criminal and non-criminal domestic violence activities over a period of 10 years.

There has been a dip in the total cases (both criminal and non-criminal) in Canada with respect to the above cited data. Following the trends, it has been noted that there has been a 30-percent reduction in the domestic violence (criminal) cases whereas, there has been a 28-percent decrease in the domestic violence (non-criminal) cases in the time period 2018-2019. Overall, in the tenure of 10 years (2009-2019), there has been a total drop of 16-percent in both the criminal and non-criminal domestic violence cases. Technological interventions might provide a deeper insights in regards to the reduction in the domestic violence and help in the monitoring of the same. It can be valid possibility that because of the technological intervention, the global rates come down because of an organized monitoring of all the data.

Figure 3. The homicide cases that appeared over the years in US over a period of years.

Here, we can find that in the term of 2016 and 2017 the homicide cases are stable. However, comparing the cases back in the 1950s and comparing now, we have a potential increase of about 21-percent in the total homicide cases all around the U.S. Moreover, according to the 14th Annual

Domestic Violence Counts Report [4], some of the important instances have been notified quantifying the importance of such an invention. According to the report, on a 24-hour hot survey, the team answered 19,159 calls related to the helplines for the domestic violence refugees and those who required help for the same. The average went up to answering 13 calls per minute. The report also suggests education be one of the important factors contributing to the domestic violence case and hence they have proposed an educational-based approach to counter the problem. However, [5] has notified something different. Their study has proven that education did not affect the cause of domestic violence. Some of the insights sought in the report state that about 35-percent of middle-eastern women are victims of some form of domestic violence, whether physically, sexually or emotionally, and verbally. And now, medical councils are also considering to be one of the important causes of depression and other mental health disorders. There is a requirement of some important interventions that would potentially address the problem and would be able to apply for a long term basis.

3. Problem Statement

Technological interventions might provide deeper insights in regards to the reduction in domestic violence and help in the monitoring of the same. It can be a valid possibility that because of the technological intervention, the global rates come down because of organized monitoring of all the data. Based on the following some of the important notes to be considered before designing the required components would be:

- Preparing a universal model, for all the demographics
- Considering the average income, the prototype and the final product has to be cheap.
- The device must be strong enough to sustain any physical loads and stresses and protecting the inner components from breaking down
- The device should be easy enough for any consumer to be able to re-assemble in case of any small technical or physical difficulties
- The model has to be properly trained and access all the important sounds and get rid of the 'False Negative' values generated during the process of detection. However, there would be an option to manually send a notification but that would be present entirely to the domain of the user

The device has been thought to be providing aesthetically pleasing appeal as a disguise for its actual function. This would be acting as an artifact of gesture and object of viewing, whereas its main function would be to keep an eye and ear around the house.

4. Design Workflow

The device has been designed to fit into the scenario of normal lives and has been preferred a minimalist design. The architecture can be easily replicated. Complex designs might create electrical and structural loads and hence to reduce the materials and the design has been preferred as light and appealing as possible.

Figure 4. The device workflow in a simplified version.

92 4.1. Start

93 The start of the workflow. Here, the device has started functioning and all the functioning modules
 94 are turned to the state 'ON'. The programming has been installed and the memory has been set to zero
 95 states. The device functions nothing important technically in this step. The initialization of the device
 96 is the first step to its implementation.

97 4.2. Device Detects Sound

98 After the initialization process, the device resumes to the state of zero or 'ON'. This is the step of
 99 re-initialization and in case of an anomaly in the entire process, the device would reach this zone. The
 100 device starts to detect sound with the sound module system attached to it. Research suggests that the
 101 normal sound-level in a middle-class Indian family is 51.5dB. This data is true for families that live in
 102 moderate-to-metropolitan cities. The device has been set to carry an offset of 5dB.

103 4.3. Sound (Beyond THRESHOLD)

104 The threshold has been set by the product producer and not by the owner. However, the product
 105 specifications, especially regarding the threshold value, shall be considered after having a physical

inspection of the house of the owner. A quick inspection of the environment of the owner would be essential for the proper functioning of the device in field operations. Whenever the set value of the threshold exceeds, the main function of informing the authority is triggered. The device is equipped with a connectivity option that would be linked to the connection of the higher authorities and whenever the threshold exceeds, there would be message information of the product filing and the details of the address (to which the product has been registered). The author has to reassign the address if there would be any changes required to be made in any shifting. This would ensure the safety of the user and would make him/her under the tracking list of the authorities.

4.4. Information Transmission

This is one of the most crucial implications of the device. The transmission of the information to the higher authorities is a delicate fact. Some information are needed to be kept away from the authorities while others needed to be transmitted. This can be a big problem as the machine would be unable to confirm the fact on which one is to be a false negative and hence for the confusion to be diminished, it has been decided that the final decision would remain in the hands of the user. The information transmission would only be possible if the user wants the information to be transmitted. However, a time limit has been set for it. If no responses are received in the given time period then the authorities are bound to act.

5. Initial Design Concepts

The product went through several iterations of changes including the changes in the material design and the shape of the final prototype. Some of the variants of the thought designs are presented. These designs have been prepared using the data of the households and considering the scenarios of some of the important aesthetic domains that might be used as a positive trait.

Figure 5. DES001: Basic side view of the product. The product has been provided with an oval shape for the dissipation of any form of load or stresses that might occur due to sudden impacts.

Figure 6. DES002: Another design concept stating the descriptive nature of the product.

Table 1. This table considers some of the advantages and disadvantages of the initial designs.

Designs	Advantages	Disadvantages
DES001	A banking angle was produced that would reduce the risk of the impact factor if the device accidentally falls into a hard ground	The shape needs to be expanded because of the enhancement in the required technical stack for its functioning
DES002	vertical module; small enough to keep in front of a table and camouflage itself with the environment; The product would become portable	The product would become incompetent as due to the locomotion, it might catch some unwanted sounds that might affect the accuracy; Less shielded towards the load stresses

Some important aspects needed to be considered while designing the final product for market usages:

1. The production cost has to be lowered
2. The maintenance cost has to be lowered
3. The environmental conditions required for the proper functioning of the device need to be catered because this is the critical function of the device (A requirement of the abolishment of the False negatives)
4. The final product must be aesthetically pleasing
5. The device configurations would vary from person-to-person and from consumer-to-consumer

6. Materials and Methods

The hardware modules chosen are some of the readily available parts in the market. This section would provide an introduction and a detailed description of some of the important components required for the building of the product.

6.1. Raspberry Pi Zero W

The Raspberry Pi Zero W belongs to the family of Raspebrry Pi microprocessors or mini-computers. This module has been officially tested to be one of the key innovations in regards to the implementation of mini-computers by the Electromagnetic Compatibility Directive (EMC) 2014/30/EU and the Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU.

Figure 7. The ARM11 Architecture.

Raspberry Pi Zero W uses ARM11 architecture. The ARM11 architecture uses the ARMv6 instructional set architecture. So basically it has two instruction sets - 32-bit ARM and the 16-bit thumb. The 16-bit “Thumb” instruction is used to make use of implied operands and reduced functionality to reduce code size. This would eventually help in the selection of the audio components and finding the required set of implied sound signals that would eventually trigger the action of informing the higher authorities. This module of Raspberry Pi is quite similar to that of the Raspberry Pi Zero. However, some of the key elements that are considered for the choosing of this module is:

- Bluetooth 4.1 (BLE)
- 1 GHz Single Core CPU
- Micro USB Power
- 802.11 b/g/n wireless LAN (key aspect in regards to quick information retrieval)

6.2. Audio Recording Device

The primary sound recording device used for the recording of the sound and storing the generated data in the memory. The microphone specification is not included in the extended documentation of the processor. For this paper, AE Microphone (3.5 mm) has been preferred. Lavalier microphones have been chosen and are preferred for this task because of their flexibility in usages and the range of detection of sounds is admissible. Microphones apart from the lavalier microphone can also be chosen and it entirely depends upon the flexibility of the owner to utilize the prediction efficiency. But as the microphone range increases, there has been an increased usage of memory noticed that might, in turn,

reduce the efficiency of the control panel of the device because of the drainage of the memory. Hence for the same, a recording device with a low sampling rate is considered.

6.3. Audio Processing Driver

The audio driver is used as an interface for the audio recording device and hardware of the microcontroller. An audio driver generally has an input and an output. The input is used for recording the sound into the computer-readable format while the output channel is used for the transmission of the computer formatted audio signals into bearable forms. For the experimentation of the device, the output channel has not been preferred because, in any instances of the functioning of the device, there is no requirement for the transmission of audio signals into a human bearable form. The removal of the output channel also diminishes the memory usages because a substantial amount of memory is required for the transmission and conversion of computer-synthesized audio signals into human perceptible sounds. Audio drivers are readily available and anyone can be used for experimentation. The sampling frequency, as usual, has to be kept low.

7. Software Modules

The device needs to interact with the environment and for that, we need efficient software modules that would act as an interface with the functionalities of the device and the environment. The two major components of the device, in terms of software implementation, is:

- Audio Receptor
- Audio Analyzer

For the audio receptor, we can move with two different processes. One would be using the existing recognizer software module that would detect the sounds in a real-time manner and would eventually show us the results effectively. But that system would be requiring efficient internet connectivity for functioning because the system would then needs to be connected with large sample datasets over the cloud. Another method would be to prepare a novel system that would be working just using the sound threshold dataset and would eventually work on that basis. This process has a big flaw because of the lack of a proper dataset that would process the learning. Generation of false negatives is more likely here and might reduce the efficiency of the software and the device. For the system to work, we have preferred the real-time bases sound recognition system provided by Sapiens SpeechAPI.

This API is free to use and comes with amazing facilities like the noise suppressor and the speech classifier. A suppressor is a tool that would eventually suppress the background noise like the wheezing cars and other environment situated noises and would obtain the main data for processing. The primary task of the API would be the reception of the sounds and find the sounds that would eventually lead to the functioning of the device.

For the audio processing part, the device would rely on mathematical calculations. MFCCs would be calculated from the audio excerpts. The MFCCs would be the main system for learning the patterns in the sound and finding the one with proper details that would contact the further ends. HMM (Hidden Markov Models) are designed that would be useful in the modeling of the learning system using which the device would be able to learn the modulations in the voice parameter and would be able to make the decisions based on the same. The HMM has been modeled based on radial distance. For a particular distance, the voice should change, and hence for accuracy, the device has been modeled such that it can incorporate all the variations in sounds by that of the distance of the sound source from the device.

8. Complete System Architecture

This section would provide a brief introduction to the whole system architecture of the device. The schematic diagram would basically be a line diagram showing the connections of the used component

210 of the microcontroller and the other linked devices and how would their position be placed in the
 211 prototype.

Figure 8. The complete system architecture showing the important connections in the device to that with the microcontroller.

212 9. Prototype Design

213 The design has been based on the designs that people usually prefer in their homes and hence
 214 enhance the aesthetic nature of the environment. The prototype model has been tested under various
 215 physical loading conditions to test its strength in various environmental conditions.

Figure 9. The prototype rendered version of the product.

216 The following design has been prepared considering the usages of aesthetics and lampshades
 217 in homes. The product has been prepared specifically to hide its main function. The hardware
 218 components [as described in the above section] would be incorporated into the device in the black
 219 region. The region has been incorporated with enough space to contain the components and work in
 220 silence. Since this is not a so much high-computation job hence the requirement of the cooling purpose

to the modular hardware has been reduced to nil. The covering of the lamp has been rendered to Plastic (Cloudy) texture to dissipate light and scatter in all directions. The function of the lamp would be performed following the standards.

9.1. Materials

The material of the base of the modular lamp has been chosen to be ABS (acrylonitrile-butadiene-styrene) Plastic. Because of the high-functionality and mouldability, this is a popular choice among design engineers. Because of the varying range of working ability and ability to work at different temperature zones, this material fits best in this context. However, other materials, including PC (Polycarbonate) might be chosen. But ABS has got the lead because of the extensive availability and feasibility of the material. ABS plastics also has a wide variety of operations when mass production is considered. Some of the important parameters of the ABS Plastic material are:

Table 2. Mechanical properties of ABS Plastics used.

Parameters	Values
Density	1.01+e3 - 1.21+e3 Kg/cubic-m
Tensile Strength	2.76+e7 - 5.52+e7 Pa
Young's Modulus	1.19+e9 - 2.9+e9 Pa
Poisson's Ratio	0.35 (at room temperature)

For making the shaded part of the lamp, the polystyrene material has been chosen. Being one of the easily available and ready-made designable accessories, it has been the best choice available. Polystyrene material is useful for modular and flexible approaches and would be available for further developmental purposes. Some of the important mechanical properties of the material observed are mentioned:

Table 3. Mechanical properties of Polystyrene used.

Parameters	Values
Density	1.07 g/cubic-cm
Tensile Strength	34 MPa
Young's Modulus	3 GPa

10. Discussion

The paper deals with a novel approach to solve an important social hazard and hence aims to manifest the idea of technical intervention in the domains of sociology and human analytics.

The paper introduced to a brand new method of interfacing the important aspect of social crime and this method might provide researchers with enough data to understand the mindset behind these crimes and such that they can be thoroughly understood and a rehabilitation method can be provided to diminish the concerning effects of the same.

One major drawback of the device is that it requires the user to feed its voice into the system for a couple of hundred times and even more from various settings possible otherwise the system won't be able to run iterations based on the previous data and would generate false alarms. Once the voice of the user has been fed into the model then the device would eventually be able to grasp all the variations in the air and find the user's voice with appropriate distant parameters and voice patterns.

Conflicts of Interest: The author declares no conflict of interests

References

1. UN, T. Declaration on the elimination of violence against women. *New York: UN* **1993**.
2. WHO, T. Violence against women. *New York: WHO* **2007**.
3. Ali P., McGarry J. , L. Classifications of Domestic Violence and Abuse. In *Ali P., McGarry J. (eds) Domestic Violence in Health Contexts: A Guide for Healthcare Professions*; Springer, Cham.
4. Domestic Violence Counts: Census reports
<https://wscadv.org/resources/domestic-violence-counts-census-reports/>
5. Noughani, F., and Mohtashami, J, T. Effect of Education on Prevention of Domestic Violence against Women. *Iranian journal of psychiatry* **2011**, 6(2), 80–83

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

© 2020 by the author. Submitted to *Inventions* for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).