Sindh Univ. Res. Jour. (Sci. Ser.) Vol.48 (2) 327-334 (2016)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Ambient Volume Controller–Exploiting Proximity Noise to Mitigate Hearing Impairments and Assist Mobile Phone Users

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Received 09th July 2014 and Revised 27th December 2015

Abstract: People raise speaker volume during conversation on mobile phone as proximty become noisy, and do not lower it down when noise level decreases. Presented work help to mitigate hearing impairments, caused by excessive use of mobile phone users of all age groups. Work has been carried to automate in-call speaker volume with respect to comfortable hearing level of phone users and make use of audible preferences in rushy or noisy areas, where it is inevitable to raise speaker volume manually and keep the level of speakers at audible level. However, maximum volume level is not required afterwards in the areas with serenity and calmness. Presented work can also help as assistive application for hearing impaired people. Stereo channel technique used to simultaneously handle in-call microphone and secondary microphone for noise scanning to appropriate adjustment of speaker output volume level. It work perfectly at comfortable hearing level of a person and automatically adjust (raise/ lower) speaker volume as context noise varies. It can further be enhanced to boost speaker volume to replace conventional hearing aid. Considering power, 5% battery power can be saved by presented application.

Keywords: Assistive technology, Environment noise, Hearing impairment, in-call volume, noise control, phone volume, volume control.

1. INTRODUCTION

The presented work focuses the frequent use of mobile phone which is the cause of docile hearing loss (García *et al.,* 2005), rise in number of ownership and use of mobile phone among people around the globe is one of the cause of hearing impairment. Therefore, public awareness is very much required and injudicious use of mobile phones must be carefully noticed (Olaosun *et al.,* 2014). Long term use of mobile phones has the potential of hearing loss (Fligor, 2009) and (Traynor, 2011). World is prevailing with people having considerable level of hearing impairment. Around 600 million people worldwide having mild to worse level, and around 250 Millions are having moderate to worse level of hearing impairment; in which 67% people with hearing impairment are living in third world countries. (WHO, 2011) study shows that in year 2025 around 900 million people worldwide will suffer from hearing loss with hearing impairment level of more than 25 decibels; among them 90 million people will be Europeans. Estimated number of hearing impaired people in North America is more than 8%. Nevertheless, preventive measures can cut half of these hearing losses worldwide. The cost of healthcare in third world countries makes it unaffordable (Colin 2000-2003). Hearing problems often found in young generation due to listening to and talking on mobile phones at high volume levels. Study shows that around 13% of kids between the ages ranging from 6 years to 19 years suffer from loss of hearing as a resu lt of high volume level in mobile phone (Kendrick, 2014). Inevitable calls from the street, and the cacophony of traffic noise, street people shouting, and construction noise makes it impossible to conduct a simple phone conversation (Bernard 2014), which causes hearing stress. Continuous use of ear buds with an integrated microphone causes hearing impairments as well. The real world will always be disruptive by mobile devices that need to be dealt (Migue, 2014). **(Table-1)** shows daily noise level exposure with a certain time interval which may potentially cause damage to hearing and make anyone to become hearing impaired person. Background noise is a real problem in many call centres as well, the noise is transmitted down through the phone to the customer and agents can find it difficult to think (Noise-Induced Hearing Loss, 2014).

Table 1: Damaging noise level and exposure per day

Occurrence of damage at (noise level in dB)	Duration of exposure per day (in Minutes)
95	140
100	120
105	60
110	30
115	15
above 119	Immediately

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People experience sound in environment, such as the sounds from television and radio, household appliances, and traffic. Normally, these sounds are at safe levels that don't damage hearing. But sounds can be harmful when they are too loud, even for a brief time, or when they both loud and long-lasting. These sounds can damage sensitive structures in the inner ear and cause Noise-Induced Hearing Loss (NIHL) observed in (Nemours. Hearing Impairment. 2014). ringing or buzzing sound in ears after going to a party, concert, or other really loud event is called Tinnitus and it usually lasts until ears gradually readjust to normal sound levels. Experiencing tinnitus or having to yell to be heard is both signs that the environment around us is too loud (Android. Telephony Manager. 2015). Motivation to develop ambient volume controller is to intelligently control voice quality and volume, to ensure the important conversation, also for helping people with hearing impairment, to automate speaker volume by changing noise threshold frequency and audible volume parameters, to ease people to listen call clearly and comfortably with no pressure on ears, this does not need to plug any auxiliary hardware as it makes use of stereo mic.

AVC (Ambient Volume Controller) may work everywhere at every time. It also has an ability to control speaker volume by itself. Ambient Volume Controller frequently change volume of speaker when person will be on call session this app will very helpful for user, Instead of to bothering frequently to turn up/down speaker volume manually; this application provide facility to automate speaker volume according to environment noise for example if user is in noisy area like factory, railway station or driving, the application adjust speaker volume so that user hear clearly or if user is in quiet environment like office then application adjust speaker volume accordingly.

It is observed that almost every person start shouting during mobile phone conversations if environment is noisy or become noisy during conversation; causing more noise pollution as shown in **(Fig. 1).** Majority of us especially outdoor workers working in noisy environment with high noise raise the speaker volume to hear the person on the other side, in noisy environment and do not even bother or remember to lower down the speaker volume when environment become serene and calm; putting stress on ear and hearing level gradually get disturb causing hearing impairments of certain type too. For a comfortable voice conversation is it learned that there must be measures to tackle this situation and automatically raise and lower down the speaker volume level to user's customized comfortable hearing level by taking environment noise percepts and actuate speaker accordingly.



Fig. 1: Ear/hearing adjustment by moving people in-call with environments' noises

2. RESEARCH MODEL

The proposed model for captioned task is illustrated in **(Fig. 2)**. Four techniques can be used for this purpose and description of these are listed below:

A. Through wired jack microphone is used same time by checking first status of jack plug-in and then force internal microphone to start by 'setaudiosource' (voice communication) method and record audio with wired microphone in another thread for using this approach headset microphone is needed, female splitter to use only microphone without speaker but this is useful only for recording purpose and cannot direct built-in microphone for voice communication when wired microphone will be plugged in.

B. Through Bluetooth microphone both microphone can be run using threading after detecting Bluetooth microphone and no internal microphone will stop for using this approach Bluetooth speaker is required. But this is not stable solution yet.

C. Through camcorder/dual microphone both microphones can be used at a time using stereo channel method no need for extra threading. No need for external resources only Smartphone with dual microphone required.

D. Through stereo channel audio can be recorded from built in microphone while on call when device have stereo microphone. **(**used in presented work)

Telephony manager provide access to information about the telephony services on the device. Applications can use the methods in this class to determine telephony services and states, as well as to access some types of subscriber information. For example, 'call_state_idle'; for no activity, 'call_state_ringing' for call is ringing now both in incoming/outgoing cases and 'call_state_offhook' for call session started both in incoming/outgoing cases. Whenever state will be changed here now it will check that is telephone state is on off-Hook then threading process will be executed

and thread will be start after this loop will be start which run process until telephony manager state is in off hook if other state found it will stop thread if not then it will record environment noise from microphone using media recorder API and then it will get speaker volume to be set using noise manipulation algorithm and the audio manager API will be call and audio will be set on call this process continue unit thread is started (Andriod. Media Recorder. 2015) (Wikipedia. Voice frequency. 2014)

2.1 Proposed model to manipulate noise level and set speaker volume

In proposed work noise level is detected using stereo channel as almost all smart mobile phones have stereo microphone; not only this the design of this application is made in such a way that if device have camcorder microphone (as used in noise cancellation apps) then the source for detecting audio (as environment noise) during call will be directed to camcorder microphone else it uses stereo microphone. Based upon noise level during call, application decides the level to set speaker volume. Using built-in microphone audio recording cannot be done as it engages on-call session. Therefore environment noise is recorded using secondary source as discussed**.**

2.2 Detection of noise in-call session and points of reference

Humans can normally hear voice clearly at 60-65 decibel and according to proposed model, if environment noise level is less than 60 for example 10db for normal breathing or 50db for rainfall decibel than the speaker volume set to normal level and if noise level is greater than 65 for example 70db for freeway traffic then speaker volume set on maximum. When phone call is received or outgoing call is made from mobile which have Ambient Volume Controller **(Fig. 3)** then telephony manager API will be called.

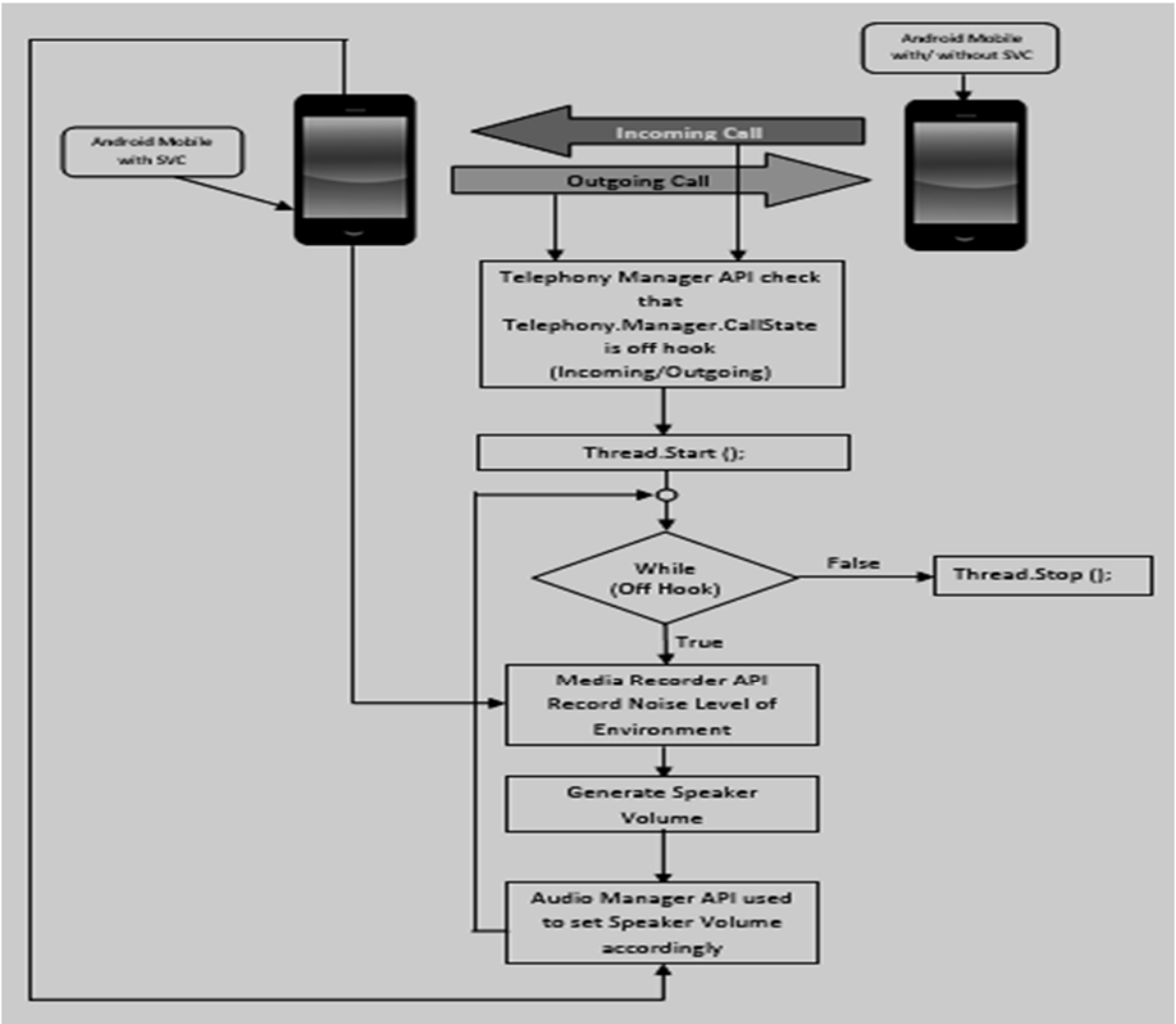


Fig. 2: Workflow of research model for proposed application

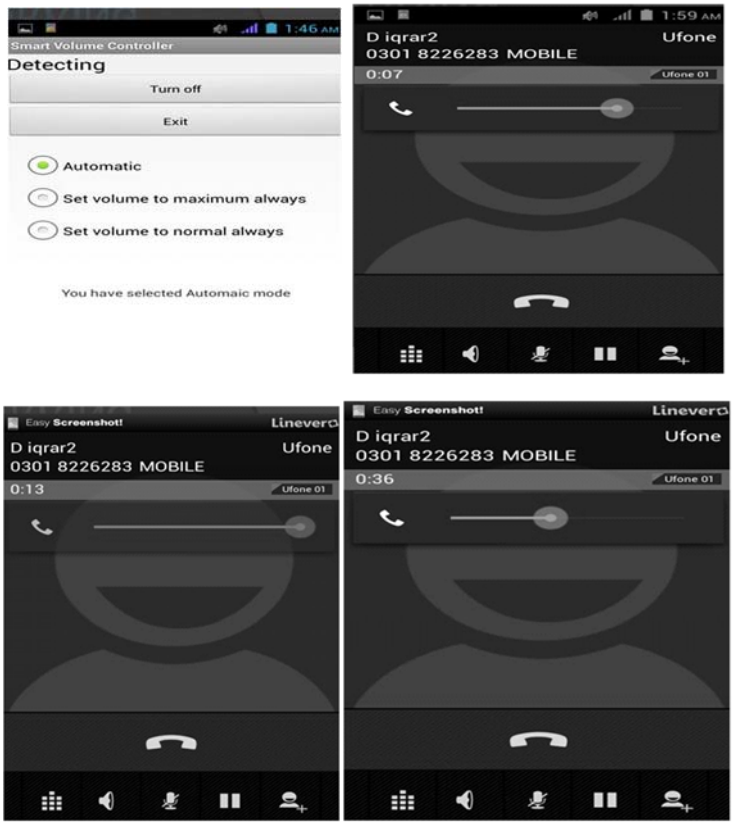
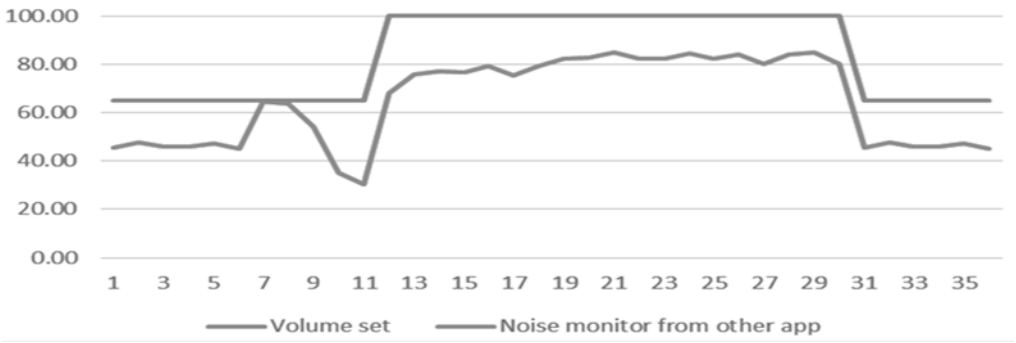


Fig. 3: AVC auto-adjusting speaker volume during call



3. RESULTS

Performance of functionality of this application has been tested in different scenarios to validate volume level variation by this application and found perfectly working on various noise levels; by making calls 6 times in different places and assured correctness as shown in **(Fig. 4 and 5).** Distinct observations of 100 minutes each have been taken for testing using smart phone at one of Pakistan's GSM network. In the first experiment, without AVC installed on phone; analysis considered that the battery discharge was 2-3 points every 10 minutes. First call made at 100% battery level and after 100 minutes call battery was found at 67%; therefore battery usage for overall call without AVC was 33%. During next observation, calls made with AVC installed on phone. This time result was almost same with 1% negligible difference. When observation started and first call made, battery was on 100% after 100 minutes battery was at 66%. Therefore battery usage for overall call without AVC was 34%. So total discharge without AVC is 33% and with AVC is 34%. The characteristics and behavior of battery, noise and speaker volume level were observed in a wide range of dynamic environments. Approximately 1% difference in

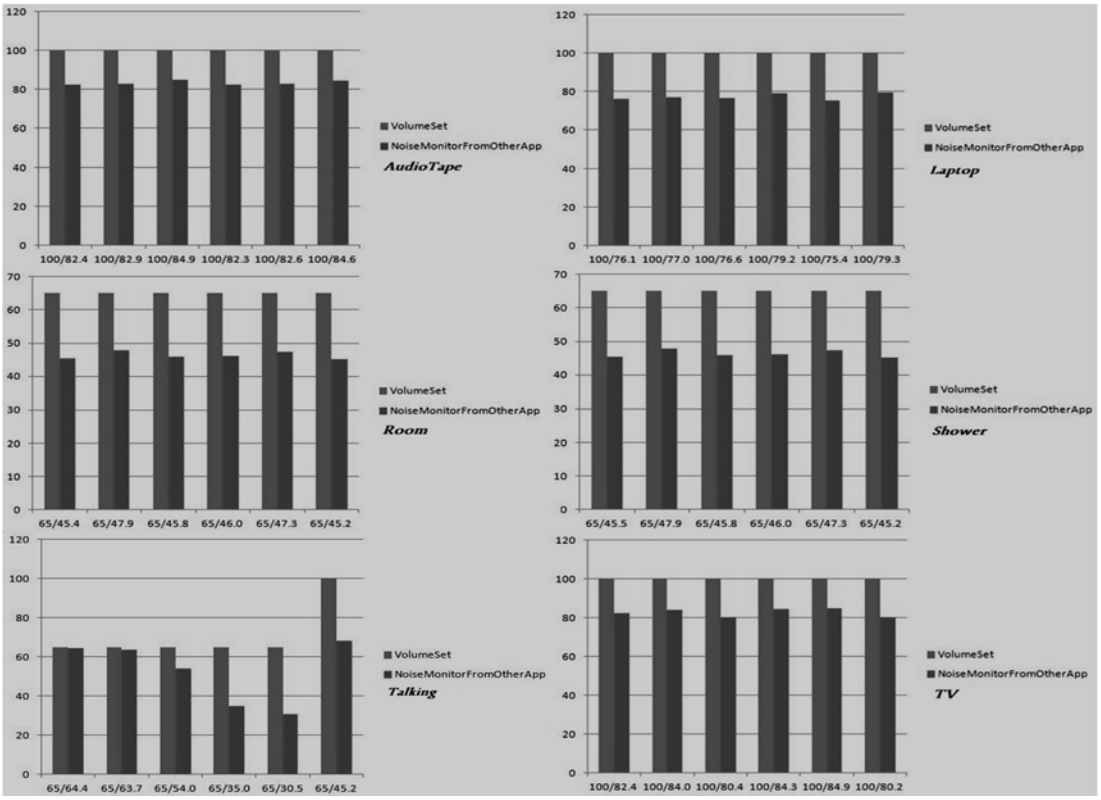


Fig. 5: Proximity noise variety vs AVC volume level set

battery power is observed during this analysis which shows a benign behavior of this application for battery power consumption; approximately up to 5% extra power can be obtained if listener is on the walk or environment noise dynamically varies. In this work we have validated the noise from noise meter and automatic adjustment of in-call speaker volume. Experiments show that application works perfectly according to the selected methodology.

4. DISCUSSION

Proposed model is tested and found working appropriately in a variety of environment nature as shown in **(Fig. 5)**. Moreover, there is no significant consumption of battery power has been found as shown in **(Table 2**) where performance of application and battery both are tested more than once, with and without A Volume Controller (AVC). Hence and interval based, speaker volume reference is proposed in **(Table 3)**. Current structure of project can easily be modified further for ringing volume adjustment or setting device to vibration/ silent on the basis of noise level in the environment. Currently the application is only useful on which it is installed but can be leverage the facility to user who is on the second end by configuring external microphone and setting microphone input level on the basis on noise level so that on the other end person can also hear voice clearly.

Table 2: Observed battery discharge with & without AVC w.r.t time

Time (in Minutes)	Battery discharge without AVC	Battery discharge with AVC
---	100%	100%
10	96%	97%
20	93%	94%
30	90%	90%
40	86%	87%
50	83%	83%
60	80%	79%
70	77%	76%
80	73%	73%
90	70%	69%
100	67%	66%

Table 3: Noise interval and proposed volume level

Perceived environment noise range for AVC	Volume Level
1 - 50	4 (0% >*X*< 60%)
51 - 70	5 (60% >*X*< 75%)
71 - 85	6 (75% >*X*< 90 %)
86 - up	7 (90% >*X*< 100%)

5. PERFORMANCE ANALYSIS

Battery performance is also tested using this application to assure that application is not affecting on battery mean killing battery so much because for any android application it is very important to assure that it will not consume battery so much and this also reflect

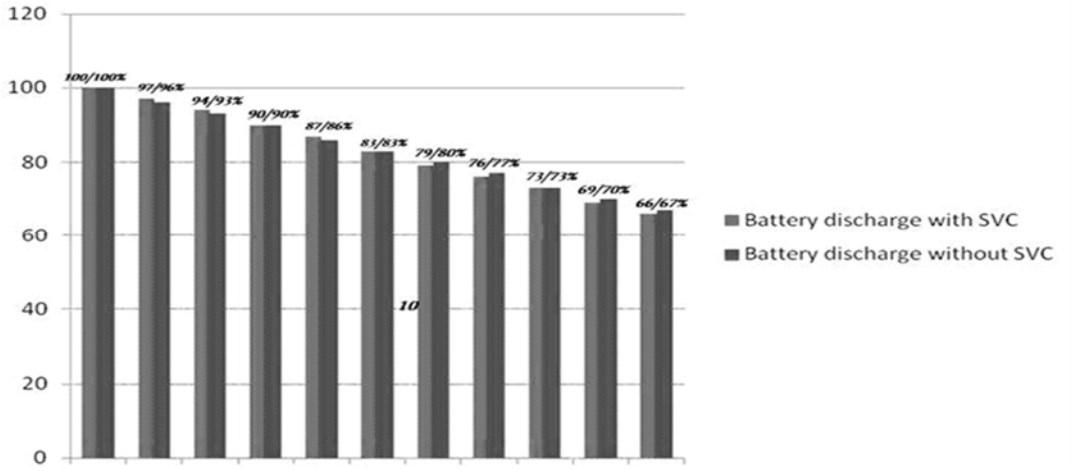


Fig. 6: Battery discharge with and without AVC

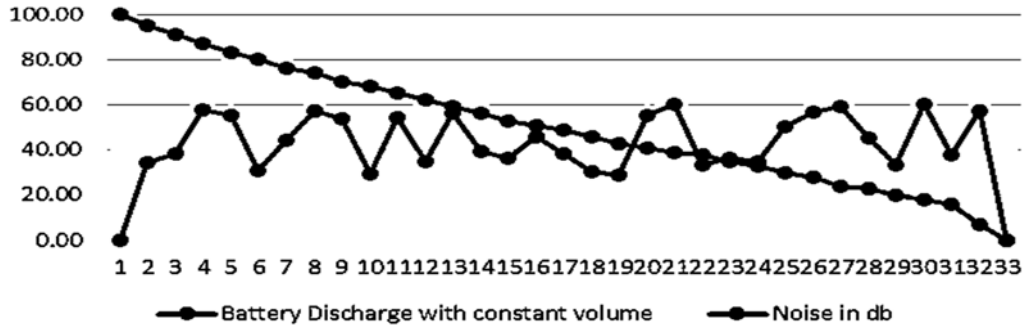


Fig. 7: Battery discharge vs noise variation with AVC at speaker volume set to comfort level

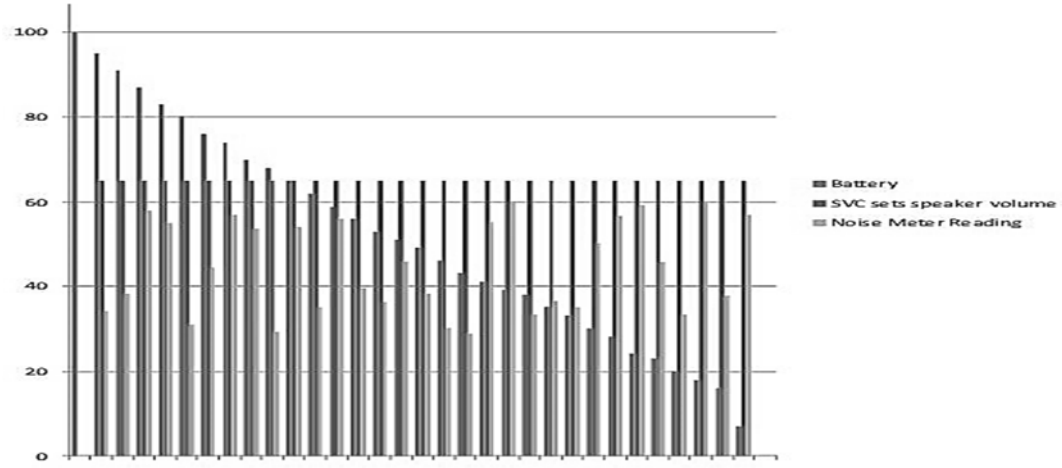


Fig. 8: AVC behavior with user-comfort level of speaker vs dynamic environment

the quality of application as shown in **(Fig. 6).** Different tests have been made on a moderate and constant speaker volume with dynamic environment noises as shown in **(Fig. 7),** and automatic speaker volume level setting in same environments and observations' result is shown in **(Fig. 8).**

We made 10 calls for observation having a 10 minutes call duration each time. First without installing proposed application and afterwards calls of 10 minutes each were made 10 times after installing proposed application on the same device.

6. CONCLUSION

The application is setting speaker volume correctly in both maximum and minimum cases, as discussed above. Among these observed environments, six environments' readings observed. This research tested mobile based automated volume controlling application in environments with a variety of noises like, T.V. Speaker, audio system, people talking and laptop music etc. The automated volume controlling model is implemented successfully using Android platform; hence shows that this research work can assist people with automated volume controlling in a noisy areas as well as in serene and calm areas. During the course of this work no wastage of battery observed as shown in results.

7. ACKNOWLEDGMENT

We acknowledge Iqrar Ahmed and Siraj Aslam, the students of department of computer science at Federal Urdu University, Karachi for their support in the development of android application and testing.

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