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ACKNOWLEDGEMENTS. We are grateful to the Director, CSIR, National Institute of Oceanography, Goa for facilities provided. Subina NS is grateful to MoES for a fellowship. We acknowledge Areef Sardar, NIO for SEM analysis and Dr C. T. Achuthankutty, for critical evaluation of the manuscript.

Received 9 May 2016; revised accepted 19 April 2017

doi: 10.18520/cs/v113/i05/965-969

Hearing impairment of Indian agricultural tractor drivers

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Noise is an occupational hazard affecting the health and safety of the tractor drivers. The hearing impairment of Indian tractor drivers has been assessed in the present study. Sixty healthy male subjects of similar age, height and weight were selected and divided into two groups of 30 subjects each, viz. tractor drivers with more than 10 years of driving experience and office workers as control. Audiometric testing of both the ears of the selected subjects was conducted at ten frequencies, i.e. 0.125, 0.25, 0.5, 1, 1.5, 2, 3, 4, 6 and 8 kHz. It was observed that the hearing threshold levels of office workers at measured test frequencies were less than 25 dB(A) and exceeded 25 dB(A) for

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tractor drivers to cause hearing handicap. Statistical analysis of the data indicated significant difference in the audiometric profile of tractor drivers compared to the office workers. The estimated average excess risk of hearing impairment of the subjects was calculated from audiometric data using five standard models; it was 0.2% and 7.1% for office workers and tractor drivers respectively. Thus it can be concluded that tractor driving significantly increased the hearing threshold levels of the drivers compared to office workers.

Keywords: Audiometry, hearing impairment, noise, office workers, tractor drivers.

NOISE is ubiquitous in the industry and has become a serious environment pollution in our daily lives in India. The World Health Organization's (WHO) Guidelines for Community Noise mentions it as a public health problem. Noise is affecting workers in every field, i.e. manufacturing, construction, transportation, agriculture and military as well as the general public. The high levels of noise not only hinder communication between the workers but also have physiological and psychological effects on them.

A concern is being raised in developing countries about the magnitude of noise exposure, particularly to agricultural machinery operators. Agricultural workers and tractor drivers experience one of the highest rates of hearing loss among all occupations. This is caused by many potential sources of loud noise on the farm, viz. tractors, combine harvesters, choppers, power tillers, threshers, etc. The long-duration exposure of agricultural workers to excessive noise may cause permanent hearing loss unless noise control measures are taken.

The American Speech Language Hearing Association (ASHA)[1] reported that hearing impairment or hearing loss is usually denoted by a change for the worse in auditory structure or auditory function, outside the range of normal hearing. A person with 85–90 dB(A) hearing loss is considered functionally deaf. The degree of hearing loss is related to the noise levels to which people are exposed. An average hearing threshold level (HTL) of more than 25 dB(A) for both ears at selected frequencies is usually denoted as hearing handicap[2].

Several studies have indicated that exposure to high noise levels leads to higher HTLs of drivers[3–5]. Majumder *et al.*[6] assessed an average excess risk and concluded that hearing loss of professional drivers could occur sooner at 3 and 4 kHz frequencies than losses at lower frequencies. Excess risk is defined as the difference between the percentage that exceeded the fence (25 dB) in an occupational noise exposed population and that exceeded in an unexposed population[2].

According to McBride *et al.*[7], the noise levels on 60 farms in New Zealand were between 84.8 and 86.8 dB(A) and hearing losses were dependent on the level of noise exposure. It was also observed that age and driving tractors without cabs were important risk factors affecting the hearing of drivers. Some studies also indicated that the noise levels experienced by operators of agricultural tractors with or without cabin exceeded the recommended limit[8–14]. The noise levels experienced by Indian tractor drivers ranged from 90 to 98 dB(A), which exceeds the recommended limit of 90 dB(A) for 8 h exposure. It has also been observed that the noise levels increased with increase in years of occupational noise exposure by the tractor operators. Kumar *et al.*[15] reported that noise levels for Indian tractors exceeded the recommended safe limits by the Occupational Safety and Health Administration (OSHA) and National Institute of Occupational Safety and Health (NIOSH) standards. Tractor driving farmers (TDFs) had more hearing loss at higher frequencies than non-tractor driving farmers (NTDFs).

Most of the studies were conducted to measure and evaluate noise levels of automobiles and tractors. However, only a few studies have been conducted to assess audiometric profile of tractor operators. A few studies conducted in developing countries reported that high noise levels experienced by tractor operators was the major cause for their hearing loss and occupational health problems. Therefore, the present study was conducted to measure the HTLs of Indian tractor drivers involved in agricultural machinery operations. It also estimated the hearing impairment of drivers with continuous years of exposure to noisy environment. The study has highlighted the effect of hearing due to tractor driving over a long period without taking any precautionary or preventive measures to reduce the risk on hearing. It has also highlighted the measures to be taken by both the industry and the drivers to reduce the risk of hearing impairment.

Sixty healthy male subjects, i.e. 30 tractor drivers and 30 office workers of the same age group with no previous history of exposure to intense noise were randomly selected for the study. The subjects were selected from Bagroda, Nabibagh and Kacchi-Berkheda villages of Bhopal district, Madhya Pradesh, India. They were divided into two groups, viz. tractor drivers with more than 10 years of driving experience ($N = 30$) and office workers engaged in sedentary work ($N = 30$). The office workers selected in the study acted as control. The demographic characteristics like age, height, weight and driving experience (mean ± SD) of the selected subjects were recorded (Table 1). The subjects were familiarized with the experimental protocol before the experimental data were collected.

The audiometric tests were performed by the audiologist at the Department of ENT, Peoples College of Medical Sciences and Research Centre, Bhopal. Each subject was asked to relax for an hour before the start of the experimental trial, and their age, height and weight were recorded. The audiometric testing of subjects consisted of air conduction, pure-tone and hearing threshold

Table 1. Demographic characteristics of office workers ($N = 30$) and tractor drivers ($N = 30$)

Parameters	Office workers mean (SD)	Tractor drivers (>10 years) mean (SD)	P-value
Age (years)	40.1 (± 10.9)	40.8 (± 11.4)	0.818
Height (cm)	166.4 (± 4.3)	161.5 (± 28.1)	0.352
Weight (kg)	64.5 (± 7.4)	60.5 (± 8.9)	0.086
Driving experience (years)	–	20.2 (± 8.9)	–

Table 2. Specifications of ALPS advance digital audiometer AD 2100

Items	Technical specifications
Channels	Two channels, with independent attenuators
Test	Frequency range (intensity)
Air conduction	125–8000 Hz (–10 to 120 dB)
Bone conduction	250–8000 Hz (–10 to 80 dB)
Special tests	Stenger test, free field, TDT, SISI, ABLB, UCL, word recognition, visual reinforcement audiometry – optional, tinnitus matching with noise.
Tone	Continuous tone, pulse tone, warble tone
Maximum hearing level	Air – 10 dB to 120 dB HL (for SPL add 25.5 dB at 250 Hz) Bone – 10 dB to + 80 dB HL Speech – 10 dB to + 100 dB HL Masking –10 dB to + 100 dB HL
Attenuator	Click-free, 5 dB
Masking	Free as well as synchronized masking, speech noise and narrow band masking
Presentation	Normal or inverse mode for all signals
External inputs	Tape recorder, CD player or microphone
Accuracy of frequency	Better than 1%

measurement at 10 frequencies, viz. 0.125, 0.25, 0.5, 1, 1.5, 2, 3, 4, 6 and 8 kHz.

A portable audiometer (ALPS Advance Digital Audiometer AD2100), which provided pure tones of selected frequencies at calibrated sound pressure levels, was used for the measurement of HTLs. Both the ears – right and left – were individually tested. The double-channel audiometer used in the study has a frequency range from 0 to 8 kHz and sound pressure intensity range from 0 to 120 dB(A). The experimental trials were conducted in a sound-proof room. Table 2 provides detailed specifications of the audiometer.

The pure tones of different frequencies and intensities were heard by the right ear through earphone and data were recorded. The test was started from 0 dB(A) for all the tested frequencies. As the intensity was increased or decreased, the subject was asked to indicate when he could hear the tone by pressing the indicator bulb switch, or when it ceased to be audible by releasing the indicator bulb switch. The lowest sound intensity that could barely be heard by the subject for each tested frequency was determined and reported as the HTL for that frequency. The threshold levels at the selected frequencies (0.125–8 kHz) were plotted as an audiogram to show hearing loss at the selected frequencies. The same procedure also repeated for the left ear of the subject. The data obtained from auditory measurements of the two groups of subjects were analysed using two-tailed t test to find out whether the mean values of the two groups differed significantly.

The five most popular models were used to estimate excess risk of hearing impairment of the selected subjects. These models were taken from the American Academy of Otolaryngology (AAO)[16], American Academy of Ophthalmology and Otolaryngology (AAOO)[17], NIOSH[18,19] and British Society of Audiology (BSA)[20]. These five models provide weightage to different frequencies to estimate excess risk of hearing impairment (Table 3). The models were used to calculate average hearing loss in the frequency range 0.5–4.0 kHz. They used low and high fences of 25 and 92 dB(A), representing 0% and 100% hearing handicap boundaries respectively. Normal hearing was represented by the low fence of 25 dB(A). The calculator developed by Kavanagh[21,22] (http://www.occupationalhearingloss.com) was used to calculate estimated excess risk of hearing impairment of office workers and drivers with more than 10 years of noise exposure. The data were analysed for age, duration of exposure and sound level of the subjects by five different models (Table 3).

Table 3. Estimated excess risk of incurring hearing impairment of tractor drivers ($N = 30$) and controls ($N = 30$)

Procedure/models	Frequency (kHz)	Average excess risk (%) (range): Office workers	Average excess risk (%) (range): Drivers with more than 10 years of experience
American Academy of Otolaryngology (1979)	0.5, 1, 2, 3	0.04 (0–1.3)	3.5 (0–35.6)
American Academy of Ophthalmology and Otolaryngology (1959)	0.5, 1, 2	0.04 (0–1.3)	2.8 (0–22.1)
National Institute of Occupational Safety and Health (NIOSH) (1972)	1, 2, 3	0.01 (0–0.4)	4.4 (0–41.7)
NIOSH (1997)	1, 2, 3, 4	0.20 (0–4.0)	7.1 (0–45.9)
British Society of Audiology (2004)	0.5, 1, 2, 4	0.10 (0–3.1)	4.7 (0–37.2)

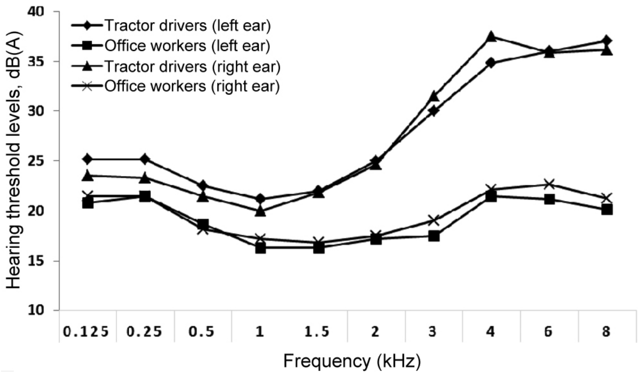

Figure 1. Audiogram of both ears of selected tractor drivers and office workers.

As mentioned earlier, Table 1 gives the mean age, height, weight and driving experience of the selected subjects. The mean age, height and weight of office workers were 40.1 years, 166.4 cm and 64.5 kg respectively. The mean age, height, weight and driving experience of tractor drivers were 40.8 years, 161.5 cm, 60.5 kg and 20.2 years respectively. The data indicated that there was no significant difference ($P > 0.05$) in the age, stature and weight of the two groups of selected subjects.

The results of two-tailed *t* test indicated that there was a highly significant ($P < 0.001$) difference in auditory threshold levels of both the ears of office workers and tractor drivers at all tested frequencies.

Figure 1 shows the variation of mean HTLs as a function of audiometric frequency (kHz) for the left and right ears of two groups of subjects is shown in Figure 1. It can be observed that the mean HTLs for tractor drivers with more than 10 years of noise exposure are higher than those for office workers. Figure 1 also shows that the average HTLs of both the ears of office workers did not exceed 25 dB(A) to cause hearing handicap. However, the average HTLs of both the ears of tractor drivers with more than 10 years of noise exposure exceeds 25 dB(A) at the audiometric test frequencies of 3, 4, 6 and 8 kHz. The average HTLs of both the ears of tractor drivers increases sharply at higher frequencies (>2 kHz). The average HTLs of the left ear of tractor drivers is higher at 0.125, 0.25, 0.5, 1 and 8 kHz frequencies compared to the right ear. Also, the average HTLs of the right ear of tractor drivers are higher at 3 and 4 kHz frequencies compared to the left ear.

Table 3 shows the calculated values of estimated excess risk of incurring hearing impairment using five models for both tractor drivers and office workers. The highest values of average estimated excess risk of hearing impairment were 0.2% and 7.1% for office workers and tractor drivers respectively, using different models. The average estimated excess risk of hearing impairment was highest using NIOSH[19] model for office workers and tractor drivers. This model calculated the average excess risk of hearing impairment for audiometric test frequencies of 1, 2, 3 and 4 kHz.

The detailed audiometric analysis of office workers indicated that they had very low excess risk of hearing impairment (0.01–0.2%). However, the average estimated excess risk of hearing impairment ranged from 2.8–7.1% for tractor drivers using different models. The highest estimated excess risk of hearing impairment using different models ranged from 22% to 46% for tractor drivers.

The present study assesses the auditory threshold profile as well as excess risk of hearing impairment of 60 healthy male subjects divided into two groups of 30 subjects each, viz. tractor drivers with more than 10 years of driving experience and office workers. Audiometric testing of both the ears of the selected subjects was conducted at ten different frequencies using an audiometer.

It was observed that there was a highly significant difference in auditory threshold levels of both the ears of office workers and tractor drivers at the tested frequencies. This finding was consistent with the conclusions of other investigators[2,6]. The average HTLs of office workers (control) at the audiometric test frequencies did not exceed 25 dB(A), whereas they exceeded 25 dB(A) for tractor drivers to cause hearing handicap of both the ears. The average HTLs were the lowest at 1, 1.5 and 2 kHz frequencies for the two groups of subjects. It can be concluded that the audiometric threshold levels are higher for tractor drivers compared to office workers (control). This might be due to the fact that office workers were exposed to low equivalent noise levels of 60–65 dB(A) during work[6]. Thus occupational hazards of tractor driving significantly affected the HTLs of drivers. It may be concluded that the audiometric status of tractor drivers was poor in comparison to office workers.

The audiometric analysis also suggested that the effect of noise levels and duration of exposure depended on frequency. The audiogram indicated that the average HTLs of the right ear of tractor drivers were higher at 3 and 4 kHz frequencies compared to the left ear (Figure 1). This may be because the human ear is most sensitive to noise between 2 and 5 kHz, and less sensitive at higher and lower frequencies. This finding was also consistent with the conclusions of other investigators[6]. It may be concluded that hearing damage at 3 and 4 kHz is expected to occur sooner than losses at lower frequencies (0.5, 1 and 2 kHz). The models that exclude higher frequencies are less sensitive to hearing loss and may require longer duration of exposure to a given sound level for significant excess risk in tractor drivers (a trend also reported by Prince *et al.*[2]). This may be due to the fact that tractors in India have exhaust on the right side. Therefore, the right ear of the operators has higher HTLs compared to the left ear.

The average estimated excess risk of hearing impairment was 0.2% and 7.1% for office workers and tractor drivers respectively. It may be concluded that the average estimated excess risk of hearing impairment of tractor drivers is higher compared to control due to occupational hazard. This highlights the need for interventions to reduce the potential harmful effect of higher tractor noise experienced by tractor drivers. The study highlights the need to take up hearing conservation programmes for occupational noise exposed tractor drivers in India.

The noise from a tractor cannot be totally eliminated, but some measures can be taken to reduce the same. The potential harmful effect of noise exposure to tractor drivers may be minimized by reducing the number of working hours per day of drivers or by the use of hearing protection devices like ear plug, ear muff, ear phone, etc. which reduce noise to a considerable extent. A closed cabin should be provided on the tractors to reduce occupational noise exposure to the operators. The tractor industry should also take steps to reduce the noise emission of vehicles by introducing improved technology like designing a low-noise engine, sound-proofing noisy parts, designing a better exhaust muffler, etc. Finally, a periodic check-up of tractor drivers is necessary to determine their auditory threshold levels.

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ACKNOWLEDGEMENTS. We thank the Director, ICAR-Central Institute of Agricultural Engineering, Bhopal and Dean, Peoples College of Medical Sciences and Research Centre, Bhopal for their support and for providing the necessary facilities to conduct this study. We also thank the staff of the Department of ENT, Peoples College of Medical Sciences and Research Centre, and all the subjects who took part in the study.

Received 25 May 2016; revised accepted 10 April 2017

doi: 10.18520/cs/v113/i05/969-974

Face recognition using a hybrid SVM–LBP approach and the Indian movie face database

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Local binary patterns (LBP) are an effective texture descriptor for face recognition. In this work, a LBP-based hybrid system for face recognition is proposed. Thus, the dimensionality of LBP histograms is reduced by using principal component analysis and the classification is performed with support vector machines. The experiments were completed using the challenging Indian Movie Face Database and show that our method achieves high recognition rates while reducing 95% the dimensions of the original LBP histograms. Moreover, our algorithm is compared against some state-of-the-art approaches. The results indicate that our method outperforms other approaches, with accurate face recognition results.

Keywords: Face recognition, hybrid methods, local binary patterns, support vector machines.

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BIOMETRIC recognition allows identification or verification of the identity from the user's unique morphological or behavioural characteristics. Among all the biometric systems, face recognition is one of the most common techniques to identify users. Local binary patterns (LBP) and its variants have been used successfully in face recognition during the last few years[1]. However, the length of generated feature vectors may cause a slow processing of face images.

The main contributions of our work are:

- The dimensions of the LBP vectors will be reduced by using PCA. Therefore, only the principal LBPs will be considered and the computation of the needed features will be accelerated.
- Next, a support vector machine (SVM) will be used so that it accurately identifies if the LBP belongs to the user to be recognized.
- The experiments are performed using the recent and challenging Indian Movie Face Database (IMFDB)[2]. There are few studies that deal with this database, due to its complexity and novelty[3,4], and no previous reference has been found using the IMFDB with the LBP algorithm. Moreover, a comparison with related methods is included, as well. No comparison on the results of different face recognition methods with the IMFDB has been reported before either.

LBPs were introduced to describe textures in images, considering that a texture consists of two complementary characteristics, the threshold and the weight[1]. LBPs encode the relationship of the central pixel g_c to the gray intensity of the pixels in the neighbourhood g_p. The value of the central pixel is taken as a threshold. Then, the LBP label for the central pixel (x, y) for each neighbourhood of P pixels is computed by multiplying the values of the threshold by the weights given to the corresponding pixels and, finally, the result is added

$$\mathrm{LBP}_P(x,y) = \sum_{p=0}^{P-1} s(g_p - g_c)2^p, \tag{1}$$

where $s(x) = \begin{cases} 1, & x \geq 0 \\ 0, & x < 0 \end{cases}$.

Ahonen[5] introduced LBPs for face recognition. Thus, after dividing the face image into R uniform regions, the histograms of the computed LBP labels for each region, H^w, with $w = \{1, 2, \ldots, R\}$ were concatenated to obtain the histogram representing a face. A LBP histogram is defined as

$$H^w(i) = \sum_{x,y \in \mathrm{block}_w} I(f(x,y) = i), i = 1,\ldots,N, \tag{2}$$

where N is the number of bins, $f(x, y)$ the LBP label at pixel (x, y) and I is the indicator function[5].