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Noise level policy advising system for mine workers

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Abstract:
A noise level policy advising system to be used by mine administrators in assigning tasks to new employees at the mine is proposed. The presented novel system uses machine learning techniques which includes clustering and classification of new employee. The mine workers are clustered using K-means to determine their properties. By comparatively using Logistic regression, support vector machines, decision trees and random forests classification techniques, the mine workers are classified. Depending on the classification, which is based on the mine workers baseline and future threshold shift, recommendations to suitable mining tasks are made. The decision tree is the best performing model with the highest accuracy. It has an average testing accuracy of 91.25% and average training accuracy of 99.79%. However, logistic regression provides the best generalisation results on the testing set. Future work would include development of a friendly Graphical User Interface to facilitate easy use of the system.

Keywords: Noise, Policy, Advising, Clustering, Classification, Logistic regression, Support vector machines, Decision trees

1. INTRODUCTION

Noise may be defined as undesirable sound lacking musical quality. The source from which noise is generated may be used to classify noise as: Intermittent, Impact or impulsive noise, Repetitive impact noise, Continuous narrow band noise and Continuous wide band noise. A direct correlation exists between the capacity of a machine and the amount of noise it produces. Large machines with greater capacity produce more noise (Witt, 2012). Depletion in mineral resources on the surface in South African mines has resulted in a need for minerals that are at much deeper level to be mined (Hartnady, 2010). This in turn requires sophisticated equipment with greater capacity which produce a lot of noise. The mining industry is therefore faced with a dilemma in which effective ways and programmes to combat Noise Induced Hearing Loss (NIHL) among the mine workers have to be devised to ensure that the hearing of the mine workers is preserved over the length of their career. The aim of this research paper is to present a novel system that employs machine learning techniques to cluster and classify mine workers at the beginning of their career and then use the classifications to assign the worker to suitable tasks in the mine that would ensure their hearing is only affected by presbycusis (hearing due natural aging) and not occupational noise.

This research paper is structured as follows: Section 1 is a brief background, it is followed by section 2 with the literature review. Section 3 has the methodology. It is followed by section 4 which presents the results and their analysis. Section 5 has the proposed future work and the conclusion.

2. LITERATURE REVIEW

The South African mines have rules and regulation for occupational noise in the mines, summed up into policies that assist administrators in decision making. The Department of Minerals and Energy (DMR) has well documented compilation of a mandatory code of practice for occupational health programme for noise. The main aim of the guideline is to enable the mine employers to include all the guide lines in their implementation of policies hence ensuring zero harm to the miners. The Mine Healthy and Safety Council (MHSC), 2014 Occupational and health safety summit milestones states that by December 2024, the total

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operational or process noise emitted by any equipment must not exceed sound pressure level of 107 dB (A) and by December 2016, no employees Standard Threshold shift (STS) will exceed 25 dB from the baseline when averaged at 2000, 3000 and 4000 HZ in one or both ears. This rules and regulations have been incorporated into the Hearing Conservation Programmes (HCP) in the mines. However, literature still shows that the implementation of the programmes has not been effective (of Minerals and Energy, 2008). The mine stakeholders are: the government, political parties, business and investors, non-governmental organizations, organized labour, communities and the media (Alberti, 1995). All the stakeholders play a role in policy formulation, implementation and monitoring. It is important for the mining stake holders to ensure that mine workers are protected from losing their hearing. Provision of early intervention methods for instance a task allocation system based on a miner's current or predicted threshold shift, is one method that can be used to combat noise induced hearing loss in the mines.

Hearing myths among the mine workers affect current policy implementation and reduction of NIHL (Reeves and Swenson, 2008), documents hearing myths among workers with regards to wearing of the hearing protection. Similar beliefs are also held by the mining workers in the South African mines. For instance, it is believed that: ear plugs are source of ear infection. There is no research that substantiates this claim. It is also believed that the eardrum can be hurt if the ear protection is pushed too far (Edwards and Kritzinger, 2012). The eardrum canal is approximately 35 millimeters long ending at the eardrum. Ear protection designers pay attention to the anatomy of the ear and therefore their designs meet the required specifications of being shorter than the length of the ear canal. The soft cartilage structure at the opening of the ear canal transforms into a bony structure when any solid object moves to close proximity of the ear drum.

2.1 Existing advising systems

The increasing occupational noise and the passing on of myths in the mines from the older generation to the younger plays a role in frustrating the efforts of the mining industry in their attempt to minimize NIHL. It is therefore imperative that a system that can be used along side the HCP be implemented. One way to deal with this dilemma would be by introducing noise level policy advising system in the mine. Advising systems have been used and are still being used in academia. These advising systems use specific markers and milestones to provide advise to students that would be essential for them to complete their studies within the minimum required time. Some of the robust academic advising system that have been developed over the years are documented by Latrellis et al. (2017). Azman presents use of Software as a tool in predicting occupational hearing loss and thereafter provide guidance in job assignment in the mines using this tool (Azman, 2017).

Hearing conservation programme officers are responsible for training and providing sound advice which should assist mine workers in preserving their hearing ability over time. When mine workers get inappropriate advice from their colleagues based on myths (Edwards and Kritzinger, 2012), it ultimately results in the frustration and damage to their hearing ability. In order for HCP to be effective, there is a need to have a data base of previous cases and the advice provided that produced positive outcomes. Keeping histories requires patience, commitment and ingenuity which the HCP officers do provide, however, they are constrained by human limitations. Hearing loss also varies across populations in the mine, this may result in the HCP officers having to deal with a lot of work. Advising can also be time consuming and mentally exhausting requiring the HCP officer to have a good ability to handle peoples psychology and to manage them.

It is in the light of the presented issues that a noise policy advising system for mine workers is proposed. These automated advising system does not replace the HCP officer but rather is used to unburden the officer thus providing extra time for specialized cases that need more attention. The system therefore complements the existing HCP and does not replace them. The system is used in the early stages of employment to profile an employee, predict their future hearing threshold shift based on the cohort that the mine falls under. The mine worker is classified and clustered, recommendations are then provided to this mine worker based on the cluster that the worker falls under. This system ensures that the mine worker is provided with sufficient hearing protection to protect them from foreseen significant hearing threshold shift that would result in Noise Induced Hearing Loss in future. These system benefits both the mine worker and the mining company.

2.2 Preliminaries

This section provides the definitions and equations of the background theory of the clustering and classification techniques used in the development of the advising system for the mine workers.

Logistic Regression Logistic regression is the type of regression used for a response variable (y) that follows a binomial distribution (Bielza et al., 2011). In training set, the logistic regression output has to be described more generally by a probability distribution and has two values: 1 or 0. Therefore, the Bernoulli distribution is assumed as follows:

$$f(y) = (1-p)^{1-y}p^y \tag{1}$$

Where $f(y)$ is the Bernoulli distribution and y is the output. However, the probability p must be located within the range (0,1). Therefore, the logistic function is defined by:

$$p = \frac{1}{e^{-\mathbf{x}W}} \tag{2}$$

Where p is the hearing loss probability for a miner, $\mathbf{x}$, $\mathbf{W}$ represent the input ,weight vector respectively.

Support Vector Machines Support vector machines (SVM) is a learning algorithm for pattern classification and regression (Graf and Wichmann, 2002). The fundamental component of SVMs is finding an optimal linearhyperplane such that the error for unseen samples is minimized (Chiu and Huang, 2013).