Measurement 91 (2016) 318–341

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Detecting of the extremely low frequency magnetic field ranges for laptop in normal operating condition or under stress

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ARTICLE INFO

Article history:
Received 4 December 2015
Received in revised form 12 April 2016
Accepted 13 May 2016
Available online 17 May 2016

2010 MSC:
78A25
62H30
80M50

Keywords:
Clustering
Confusion matrix
Extremely low frequency
Laptop
Magnetic field radiation
Measurement

ABSTRACT

This paper presents a new method for analysis and management of data, which are obtained by measuring the magnetic field emission in the laptop neighborhood. Accordingly, the extremely low frequency magnetic field radiation emitted from laptop is considered. Laptops operate in normal condition or under stress condition. Measurement is performed on top and bottom measuring positions of laptops, fed by alternating current and battery. Results are analyzed and discussed based on standard safe limit. Then, magnetic field ranges are obtained from clustering of measuring positions by K-Medians algorithm for detection of high emission levels. A comparison between ranges in normal condition and ranges under stress condition is pursued by the confusion matrix, revealing that higher magnetic field ranges are obtained when laptop is under stress. Finally, investigation of the confusion matrix confirms the distribution of measuring positions from lower range to higher range from normal to stress condition.

1. Introduction

All static magnetic fields in the extremely low frequency (ELF) domain have natural or man-made origin. ELF represents the frequency range from 50 to 300 Hz [1]. Natural and man-made magnetic fields can be discriminated by their characteristics. Particularly, the natural produced magnetic field is static or very slow in its amplitude deviation. In contrast, man-made produced magnetic field is characterized by common peaks. Furthermore, it typically emits the highest level of magnetic field at 50 (Europe) or 60 Hz (Overseas). Hence, it is related to the use of electrical power, which is firmly linked to modern civilization.

The experts from the International Agency for Research on Cancer (IARC) come to the conclusion that natural source of the earth's static magnetic field varies from 25 μT at the equator to 65 μT at the poles [2]. This level of the magnetic field emission is considered as a safe one. All other levels of the magnetic field emission are created by man-made sources. Various researches had investigated the influence of the man-made ELF magnetic field emission to the humans. Some of them recognized and proved the hypersensitivity or even bad effects to the humans' health, if they are commonly exposed to the ELF magnetic field emission. World Health Organization (WHO) in its report from 2009 concluded that the influence of the magnetic field can be spread to dermatological, neurasthenic and vegetative symptoms [3]. However, many other researchers proved much more dangerous health symptoms like arrhythmia, headache, limb pains, memory problems, muscle stiffness [4,5]. Furthermore, special attention has been paid to the effects of the human constant exposure to an ELF magnetic field in order to realize the possible leukemia and tumors development and growth. IARC monograph makes the conclusion that ELF magnetic fields can have carcinogenic effects to the humans. Unfortunately, the analyzed data were insufficient to draw a firm conclusion. Hence, it is classified only as a carcinogenic risk to the humans [2]. In spite of that, many analyses have shown that exposure to an ELF magnetic field higher than 0.4 μT can double the risk of childhood leukemia [4].

The laptop computer is commonly described as a portable personal computer, which can be used in the house, office or it can be

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http://dx.doi.org/10.1016/j.measurement.2016.05.060
0263-2241/

taken away. It is usually powered by alternating current (AC) or by its battery, if it is used for traveling. In contrast to the desktop computer, the laptop computer stands for all-in-one designed computer. Hence, it includes the following parts: (i) computer unit, (ii) input units like keyboard, mouse, touchpad, touchscreen, web camera, etc., (iii) output units like screen, speaker, web camera, etc., and (iv) battery, which are sealed into all-in-one portable computer. Despite its portability, it is a fully functional computer just like desktop one. As an advantage to the desktop computer, it can be taken away due to its light-weight and battery supplying. In this sense, the battery represents the equivalence to uninterruptible power supply (UPS), which can be added to desktop computer. However, the battery runtime is from 2 up to 10 h, which clearly overcomes the UPS runtime.

From all above, it is common that the effects of the constant magnetic field exposure in the laptop nearby are very important for each user. The risk of the ELF magnetic field exposure of laptop users has been analyzed in Refs. [4,5]. They proposed the reference limit level of the ELF magnetic field emission, which can be used as a measure of safety. The critical limit level of the ELF magnetic field exposure is set to 0.3 μT [4,5].

One of the most famous standards for the safe use of the computers is proposed by TCO. TCO is a Swedish abbreviation of the organization called the Swedish Confederation of Professional Employees (Swedish: Tjnstemnnens Centralorganisation). The TCO standards are widely accepted by manufacturers worldwide. In the TCO'05 version, it deals with the problem linked to the laptop certification. Among the other criteria, TCO proposed the measurement methodology as well as the safe reference limit level of the magnetic field exposure. In the ELF magnetic field range, the TCO (part of the TCO I band) proposed the safe reference limit at 0.2 μT [6]. Although this reference limit level looks like very strict, the TCO proposed the measurement instruction, which can be problematic to the laptop user. Particularly, it instructs the magnetic field measurement at 0.30 m in the front of and around the laptop [6]. However, the laptop users are in constant contact with the laptop keyboard or touchpad. Hence, TCO measurement instructions didn't take into account this real circumstance, which might determine negative effects to the user's health [5,7].

The magnetic field emitted by laptop computers has been previously researched. In Ref. [5], the magnetic field is measured in the range between 1 Hz and 400 kHz. The study investigated the influence of the laptop magnetic field emission to the pregnant women. The same authors in Ref. [7] tested magnetic field according to the ICNIRP standard in the same frequency range. In this paper, the authors suggested "ICNIRP filter" circuit in order to adjust the measurement to that standard. In both papers, the experiment included only 5 laptop computers. Furthermore, they didn't take into account technical condition of testing laptops used in the experiment. Also, the author didn't draw the conclusion that magnetic field level is much more dangerous in the ELF frequency range. Recent developments have shown that laptops have a much higher magnetic field emission in the ELF range [8,9]. In Ref. [9], the experiment is conducted on 13 laptop computers used in normal, i.e. "office" operation condition. The obtained measurement results are classified in order to extract the laptop positions, which are the most dangerous to the users. Furthermore, in Ref. [8] the experiment is performed on 6 laptops, but used in different operating conditions. The laptops operated in normal operating condition called without stress and using heavy graphics oriented applications, i.e. under stress. At the end, the comparison between both measured magnetic field emissions is made based on the plain data without advanced processing of data. The results showed that laptops working under stress emitted 2–3× higher level of the ELF magnetic field. Still, classification of the laptop positions for analysis of emitted magnetic field ranges in normal operating condition and under stress has not been investigated yet.

In this context, application of a machine learning algorithm is of great utility with respect to a "flat" analysis of measured data for multiple reasons. First of all, it allows to automatically infer general dangerousness classes corresponding to magnetic field ranges emitted from laptops, which are not possible to understand only "looking at" measured data. Secondly, dangerousness classes extracted from the machine learning algorithm can be associated to different laptop positions. For this reason, they are very useful to automatically quantify and characterize the most dangerous laptop positions. Single measured data are easy to analyze "by hand" on a reduced number of laptops to determine the most dangerous laptop positions. However, a strong evaluation of the most dangerous positions in a general way requires a huge number of measured data on different laptops, which is essential to better generalize the analysis. In this case, application of a machine learning algorithm becomes a very important tool. Finally, analysis of laptop magnetic field radiation by ranges extracted from a machine learning algorithm instead of single measured data is more robust and prone to measurement errors affecting the single laptop positions. In fact, a range is characterized by minimum and maximum values, and single measured values composing it are not in the focus. For this reason, analysis by ranges can be considered as a new and alternative way to conceive the measurement process.

Analysis of magnetic field ranges in normal operating condition or under stress is a very useful task to understand if magnetic field emissions higher than the reference safe limit are present in a wider scenario involving: (i) multiple sources, (ii) how much higher the ranges are with respect to reference limit and (iii) how much a heavy-loaded laptop influences the range values. All aforementioned scenarios have different impact on laptop users health as well as to the suggestions for the laptop safe use.

In this paper, the problem of the ELF magnetic field emission received from the laptops is addressed. The measurement of the magnetic field obtained from nine different laptops is performed. The laptops are tested in different operating conditions. In the normal operating condition, they are used for typical office operations like web browsing or using Office package. On the contrary, the laptops are operated under heavy load (under stress) using graphics intensive programs, too. Also, the laptops are tested when they are AC or battery powered. Then, the measurement results are presented and compared according to proposed risk standards. Furthermore, clustering is performed on the measuring positions of laptops for detection of ranges of magnetic field emission in normal operating condition or under stress. Analysis of the obtained ranges is performed for finding the highest peaks in magnetic field range. Furthermore, correspondence between ranges found in the two operating conditions is realized by analysis of the confusion matrices. A depth investigation reveals the changes of magnetic field emission between the found ranges in normal operating condition and the found ranges under stress. Finally, detailed analysis of the confusion matrices shows the evolution in the distribution of the measuring positions between normal operating condition and under stress. It is important for aligning the ranges found in normal condition with the ranges found under stress condition, in order to follow the evolution of the range from normal to stress condition.

The paper is organized in the following manner. Section 2 defines the measurement elements. Section 3 discusses the measurement results of the magnetic field emission. Section 4 describes the feature definition. Section 5 performs the clustering of data based on K-Medians algorithm. Section 6 gives the comparison of the reference safe limit. Section 7 shows the comparison between the laptop magnetic field emission in normal operating condition and the laptop magnetic field emission under stress. Section 8 draws the conclusion.