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Identification of electric field strength in aircrafts

***Abstract**. The development of new technologies contributes to an increase in the value of the electromagnetic field. The article presents the identification of the electric field with the use of cluster analysis. The research on the value of the electric component of the electromagnetic field (EMF) was determined with the NHT3DL broadband meter from Microrad with the 01E measuring probe during training flights.*
The developed model for cluster analysis using the DBSCAN (density-based spatial clustering of applications with noise) algorithm is used to identify the electric field exposure value in the context of flight safety analysis.

***Streszczenie** Rozwój nowych technologii przyczynia się do wzrostu wartości pola elektromagnetycznego. W artykule przedstawiono identyfikacje pola elektrycznego określoną przy użyciu analizy skupień. Badania dotyczące wartości składowej elektrycznej pola elektromagnetycznego (EMF) wyznaczono miernikiem szerokopasmowym NHT3DL firmy Microrad z sondą pomiarową 01E podczas lotów szkoleniowych statkami powietrznymi.*
Opracowany model do analizy y skupień przy użyciu algorytmu DBSCAN (ang. density-based spatial clustering of applications with noise) służy do identyfikacji wartości ekspozycji pola elektrycznego w kontekście analizy bezpieczeństwa lotów ***(Identyfikacja natężenia pola elektrycznego w samolotach)***

Keywords: electromagnetic field, aircraft, exposure, density-based spatial clustering of applications with noise (DBSCAN), cluster analysis
Słowa kluczowe: pole elektromagnetyczne, samoloty, narażenie, DBSCAN, analiza skupień.

Introduction

With the development of new technologies, there is growing concern among people about exposure to electromagnetic fields, both among passengers and aircraft maintenance. Due to advanced technologies related to the safety of aircraft flights, exposure to electromagnetic fields is constantly monitored and analyzed in particular, radio frequencies (RF-EMF) should be highlighted.
Electromagnetic radiation can be divided due to the frequency into ionizing and non-ionizing. As a result of ionizing radiation, chemical bonds can break, which can lead to changes in materials and biological tissues.[1-4] In the context of aircraft, ionizing radiation is natural and comes from space sources. It can be defined as cosmic or galactic rays, and the intensity of exposure during flights depends on the position of the aircraft, in particular latitude, flight altitude, as well as the length of exposure and the time of year. In the case of non-ionizing radiation, it causes thermal effects. There are few publications related to the exposure of the electromagnetic field during the flight as well as take-off and landing. Electromagnetic fields may cause effects not only related to the tissue heating effect, but also in the context of flight safety, however, some sources may interfere with devices, electronic equipment in the plane [5-8]. Research centers carry out measurements of electromagnetic field emissions in means of transport. Therefore, exposures to electromagnetic fields must be monitored and analyzed for both short-term and long-term exposure.

Method and Materials

In order to determine the general impact of the electric field strength that affects humans and electronic devices during flight with a given type of aircraft, experimental measurements were made and then the obtained results were implemented in order to develop a model for cluster analysis using the DBSCAN algorithm [9]. The algorithm's task is data mining, which consists of dividing a data set into groups in such a way that elements in the same group are similar to each other, and at the same time as different as possible from elements from other groups [10-13]. This solution allowed to filter out the results that occur with a lower frequency (Fig. 2). The analysis was carried out for the measurements of 4 types of aircrafts, such as: Aero AT3 R100, Cessna C152, Robinson R44 Raven, Tecnam P2006T, which constitute the didactic base of the Aviation Training Center of The University College of Applied Science in Chelm. This center conducts training for ATPL licenses for airplanes and helicopters as part of engineering studies. The research on the value of the electric component of the electromagnetic field (EM) determined with the use of the NHT3DL meter by Microrad was presented (Fig. 1)

Fig.1. The Microrad NHT3DL electric field meter with 01E measuring probe, installed in the Aero AT3 aircraft.

The measurement data for each of the presented types of aircraft are presented in Fig. 2.

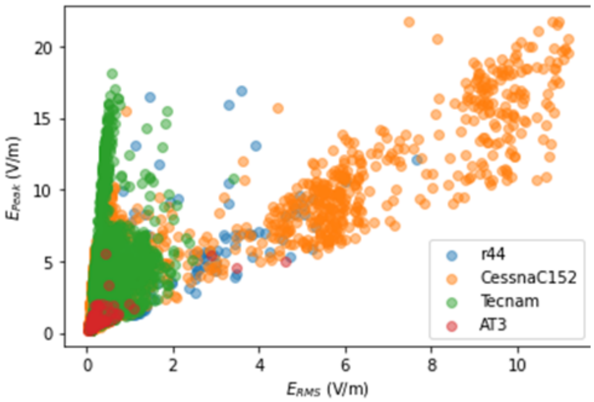


Fig.2 A point plot of the E_{RMS} i E_{PEAK} values of the electric component of the electromagnetic field for 4 types of aircraft

The DBSCAN algorithm (density-based spatial clustering of applications with noise) was used for the cluster analysis
based on densities with the adaptive parameter ϵ. DBSCAN algorithm searches for neighbors of a given point at a distance of ϵ, in the next step central points are defined, i.e. those with minimum N neighbors [14 -17]. Observations that meet the above assumptions are combined into one group, points that are within the range N and are not central points are also switched to the existing groups [18-22]. Observations that have not been attached to any group become borderline observations. An example of the operation of the DBSCAN algorithm is shown in Figure 3.

The parameter ϵ determines the maximum distance between two samples to be considered as a group. For each group of measurements, the parameter ϵ for a given airplane type was determined by the equation

$$\epsilon = \sqrt{E_{RMS}^2 + E_{PEAK}^2}$$

Where: E_{RMS} and E_{PEAK} is the mean value of the measurements

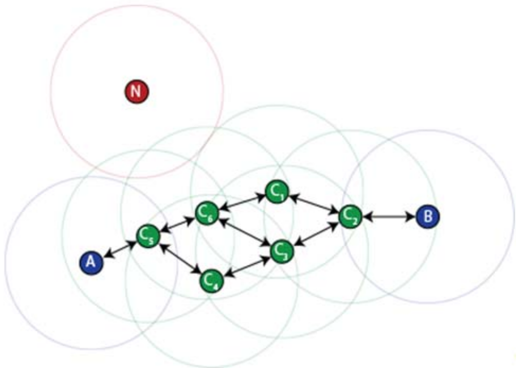


Fig.3. An example of how the DBSCAN algorithm works

In the above figure (Fig. 3) the points C represent the focal points, and A and B are the border points, point N is the outlier. For each type of airplane, parameter ϵ was determined first, according to the formula (1). Then the DBSCAN algorithm was applied with the previously determined parameter ϵ for each group. The algorithm determined the clusters and data considered as noise (outliers). The noise was filtered out and the parameters presented in Table 1 were determined for the remaining data.

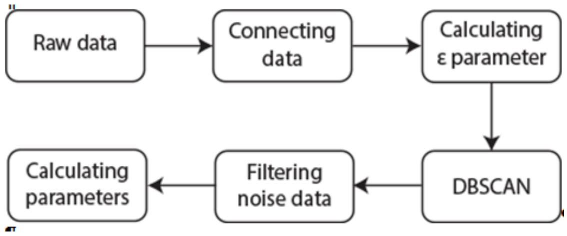


Fig.4. Diagram of the data filtration process

The minimum number of samples was set as static values and amounted to 60.

Result and discussion

The results of the collective analysis for each of the aircraft, without the use of cluster analysis, are presented in Table 1.

Table 1. Results of collective analysis for each of the aircraft

Aircraft Type	Aero AT3	Cessna C152	Robinson R44	Tecnam P2006T
The average value E Peak, V/m	0.88	2.71	2.63	3.82
The average value E RMS, V/m	0.2	0.6	0.54	0.43
The average value E (Peak/RMS) , V/m	6.3	9.36	8.57	13.32

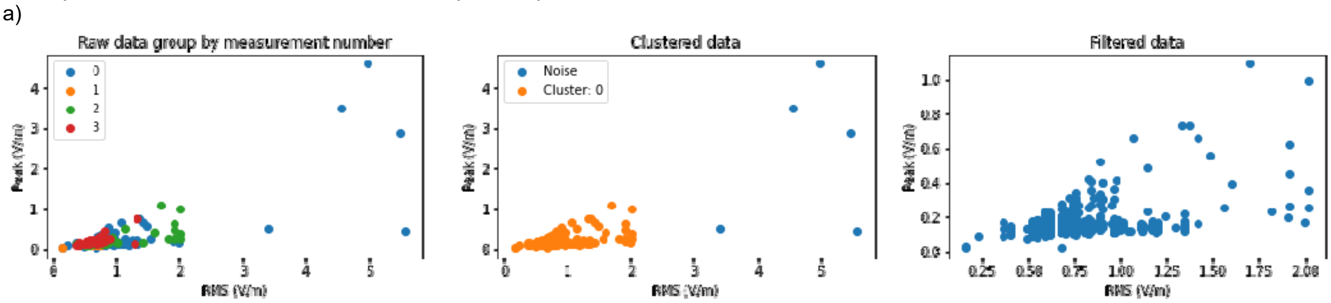
Table 2 presents the data after applying cluster analysis.

Table 2 The data after applying cluster analysis.

Aircraft Type	Aero AT3	Cessna C152	Robinson R44	Tecnam P2006T
The average value E Peak, V/m	0.68	2.06	1.88	3.56
The average value E RMS, V/m	0.14	0.36	0.33	0.32
The average value E (Peak/RMS) , V/m	5.01	9.45	6.8	12.5

The results of the cluster analysis for measurements from a given type of training aircraft are shown in Figure 4

a)



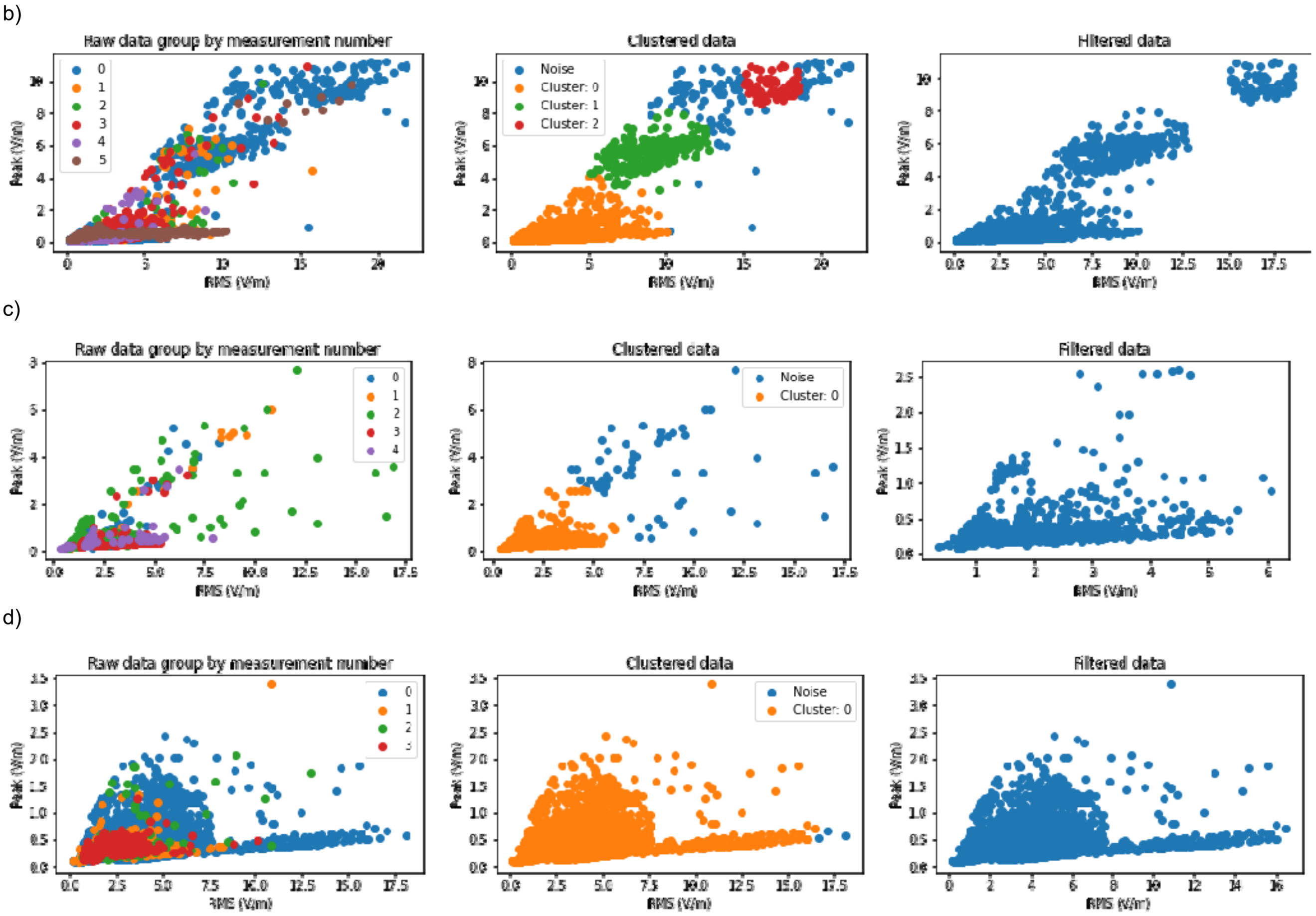


Fig.4. Cluster analysis results for aircraft electric field measurements: a) Aero AT3, b) Cessna C152, c) Robinson R44, d) Tecnam P2006T

Conclusion

Cluster analysis made it possible to determine the generalized influence of the electric field on the user during air operations with a given type of aircraft. The highest average value of E RMS = 0.36 V/m occurs in the Cessna C152 type airplane, and the highest ratio of the instantaneous values of E Peak to the average values of E RMS, 12.5 V/m was recorded during the flight with the Tecnam P2006T airplane. On the other hand, the lowest values of the electric field are recorded in the Aero AT3 for all three parameters and they range from 0.14 to 5.01 V/m. Only in the case of the Cessna C152 aircraft, the algorithm grouped the data into 3 clusters, in the remaining cases there was 1 cluster. The identification of exposure to RF-EMF has the potential to determine in which type of aircraft the lowest electric electromagnetic field scale values are present. The obtained results were compared with the permissible limit values: Directive 2013/35 / EU, with the applicable regulations of the Minister of Health of 17 December 2019 on permissible levels of electromagnetic fields in the environment, with the regulation of the Minister of Family, Labor and Social Policy of 12 June 2018 on occupational health and safety in works related to exposure to electromagnetic whether electromagnetic field normative values were not exceeded.

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