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doi:10.15199/48.2021.12.27

Aviation training safety assessment in the context of electromagnetic field exposure

***Abstract**. The article presents research on the safety assessment of aviation training in the context of exposure to electromagnetic field. Measurements were carried out with the NHT3DL meter from Microrad with the 01E measuring probe during practical training on the FNPT II class simulator and during training flights with the Tecnam P2006T plane. An algorithm was developed to assess the safety of aviation training using the Siamese neural network*

***Streszczenie.** W artykule przedstawiono badania dotyczące oceny bezpieczeństwa szkolenia lotniczego w kontekście narażenia na pole elektromagnetyczne. Pomiary przeprowadzono miernikiem NHT3DL firmy Microrad z sondą pomiarową 01E podczas szkolenia praktycznego na symulatorze klasy FNPT II oraz podczas lotów szkoleniowych samolotem Tecnam P2006T. Opracowano algorytm do oceny bezpieczeństwa szkolenia lotniczego przy użyciu sieci neuronowej sjamskiej (**Ocena bezpieczeństwa .szkolenia lotniczego w kontekście ekspozycji na pole elektromagnetyczne**)*

Keywords: pole elektromagnetyczne, sieci neuronowe, pomiary, exposure.
Słowa kluczowe: electromagnetic field, neural network, measurements, narażenie.

Introduction

The development of civil aviation all over the world has forced a constant strive to increase the level of safety. The European Aviation Safety Agency (EASA) recommends undertaking extensive activities related to the monitoring of critical elements of the flight safety system [1-3] In order to improve reliability in general aviation and to adapt to the proposed requirements, aviation training centers are obliged to introduce systems for monitoring and analyzing flight parameters. In systems where people's lives are at risk in the event of a failure, some systems are redundant or even tripled. In structures such as aircraft using computerized control systems, the element generating the wrong decision must be subordinated to the other two, and human factors will determine the pilot's lack of precise response, a disaster may occur [4-7].

A neural network model was developed to assess the safety of aviation training.

Method and Materials

The analysis of the safety of the instructors' working environment during the instrument rating practical training was carried out on the Tecnam P2006T aircraft in the context of practical training on the FNPT II simulator at the State School of Higher Education in Chełm. The electromagnetic field tests for the electric component were carried out using the NHT3DL meter by Microrad with the E01 measuring probe. In order to acquire the results, measurements were made during flights and in the simulator. The Tecnam P2006T aircraft (Fig. 1) was selected for the test. It is equipped with avionics to perform flights in accordance with the instrument flight rules(IFR) and a certified FNPT II simulator. The FNPT II Elite 912 S MCC training cockpit (simulator) is shown in Figure 2. Practical training is carried out on the basis of a training program, the aim of which is to learn to fly an aircraft based on a set of instruments, and then to learn to navigate in a controlled air space in accordance with the IFR (Instrument Flight Rules) [8-9].

The Tecnam P2006T aircraft is a four-seater high-wing aircraft designed for training tasks and also serves as air taxis. It is equipped with two 2 x 100 HP Rotax 912S piston engines, variable pitch propellers and a retractable landing gear. It is mainly made of aluminum alloys. The avionics devices include Garmin G950 Glasscockpit, Autopilot, ELT, Transponder with modem S, Traffic Alert System (TAS), NAV / COM / GPS.

Fig.1. Training Cockpit of FNPT II MCC

Fig.2 Tecnam P2006T Aircraft

In order to determine the general similarity coefficient, an algorithm for training a neural network was created. Siamese neural networks were used to compare both time series (simulator training and Tecnam P2006T). These are two identical neural networks that have been connected at the outputs. They share not only architecture but also weights, which allows to return vector values representative of the input data.

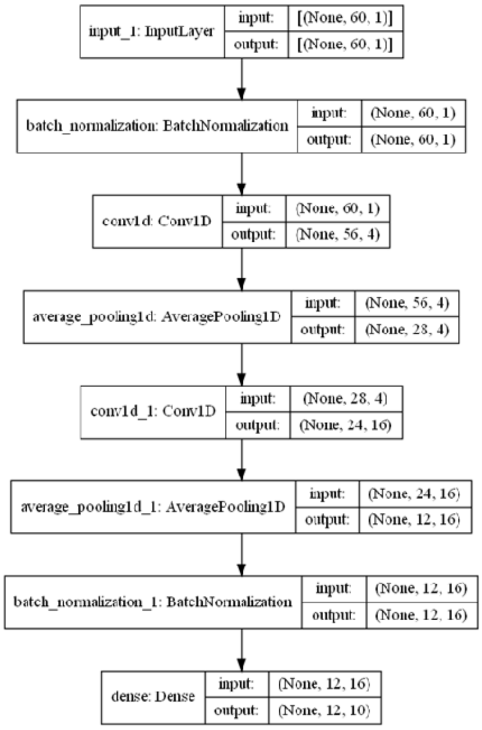

Fig.3. The structure of the Siamese network

The structure of the Siamese network, which was used to compare the time series, is shown in Figure 3.

The network consists of 2 layers: a normalization layer, 2 layers of one-dimensional convolution, 2 layers of averaged connection and one layer of neurons. The normalization layer is responsible for applying the transform, the process of which optimized the mean value of the input subset closest to 0, and the standard deviation to 1. The convolutional layer performs the convolution operation which is responsible for creating the filters, and averaged connection returns the average value of the specified parts of the data matrix [10-13].

The structure of the network responsible for comparing data is presented in Figure 4

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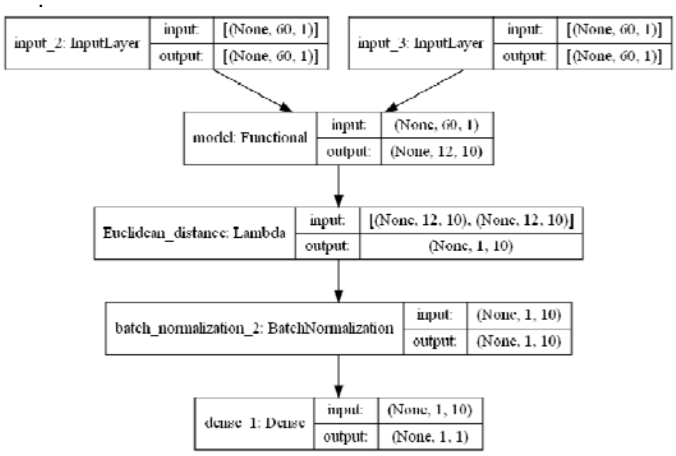

Fig.4. The structure of the network responsible for comparing data

The vectors returned by the Siamese network of networks will be compared by applying the Euclidean distance algorithm and re-normalized

Result and discussion

Using the NHT3DT meter, tests were carried out during the practical training of pilots. The electric field strength measurements during training (IR) in the training cockpit are shown in Figure 8.

Figure 9 shows the distribution of the electric field strength during a selected flight with the Tecnam P 2006T aircraft.

In order to create a model to compare the training, a network study was carried out. The actual data has been scaled in such a way that the sampling frequency is equal to the sampling frequency of the simulator data. The data obtained as a result of the measurement of the electric component of the electromagnetic field from the simulator and actual measurements during the flight training with the Tecnam P2006 aircraft are shown in Figure 6

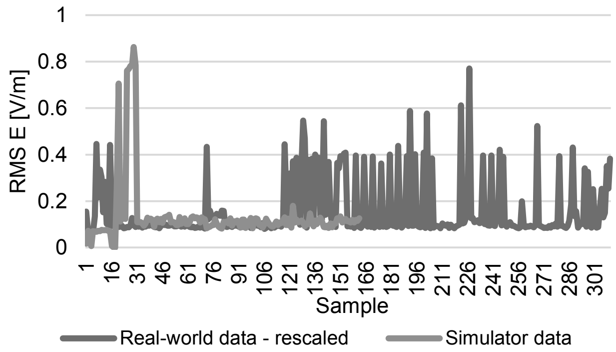

Fig.6. Measurement data from the Tecnam P2006 and simulator.

In order to create an algorithm for learning the network, the data was paired in such a way that windows consisting of 60 samples were densely linked together. The analyzed data used to create the model were divided into a set for training, a test set and a validation set. The network has been trained for 20 epochs, resulting in an accuracy of 100% for the validation and test set. Data relating to the change in accuracy per epoch are shown in Figure 7, while the loss is shown in Figure 10

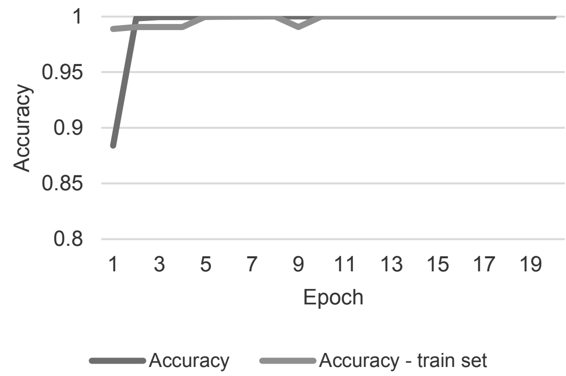

Fig.7. Accuracy per epoch

The matrix in a flattened form is shown in Figure 12

The overall value of the similarity index, which is the mean of the component similarities, is 0.00013.

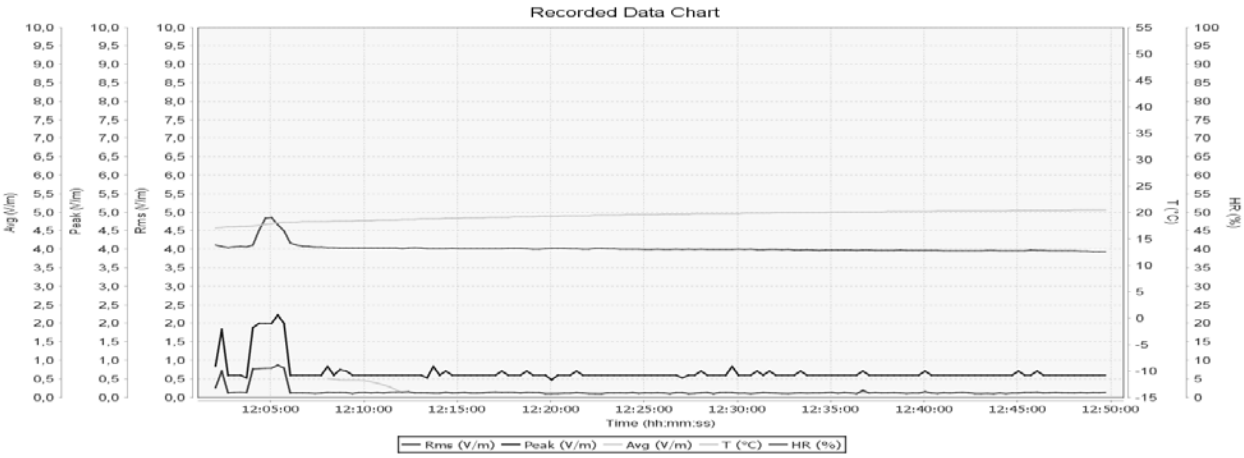

Fig.8. Electric field strength distribution during flight training in the FNPT II MCC training cockpit

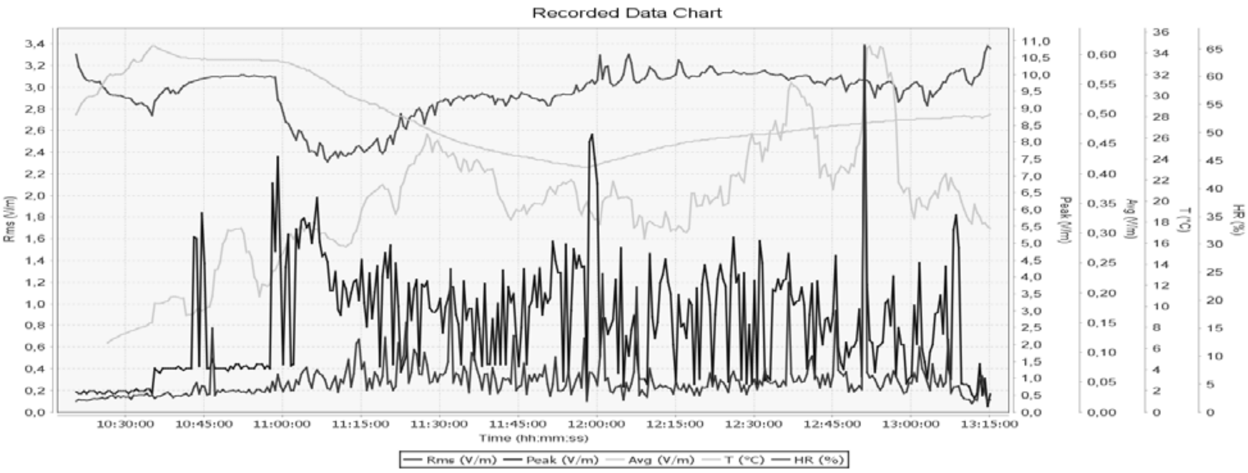

Fig.9. Electric field strength distribution during aviation training

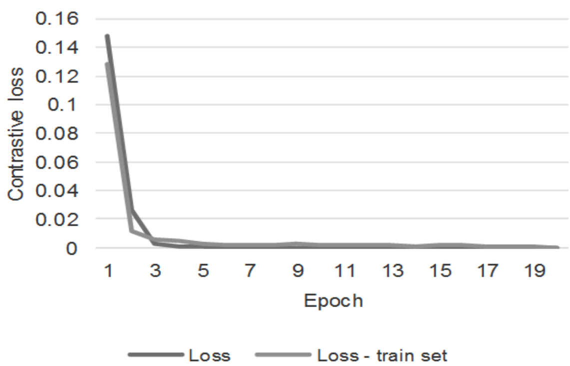

Fig.10. Loss per epoch

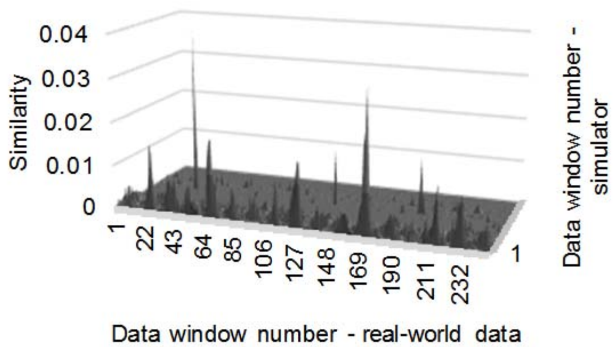

Fig.11. Similarity matrix

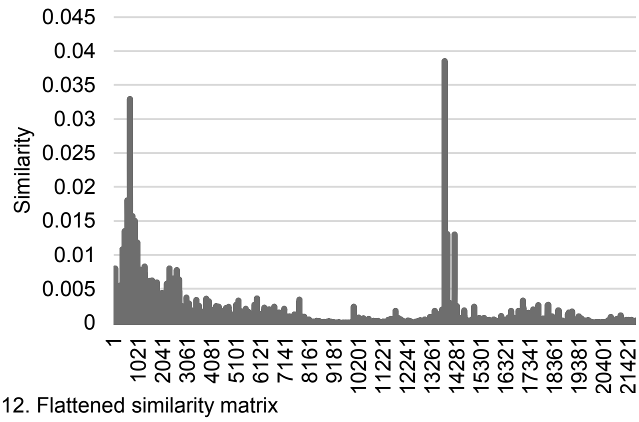

Fig.12. Flattened similarity matrix

Conclusion

During the training (IR), the highest values were recorded for *E* = 3.4 V/m where the Tecnam P2006T was on the EPLB ILS 25 approach path. It should be noted that they are higher than the training values simulated on the ILS 25 EPLB approach path in the FNPT II training cockpit E = (0.1-0.7) V/m.

The task of the neural network was to create a set of features and reduce it to a smaller dimension in order to indicate the overall similarity of the signals. The use of the Siamese network allowed to determine the level of signal similarity. Properly trained neural networks of this type can also help determine the similarity between other signals and even groups of signals. Overall, the network returned small probability indicators, so the signals are not similar to each other. It can be observed that the recorded values of the electric field during cockpit training are lower compared to flights with a training plane equipped with avionics and systems enabling instrument flights. Therefore, a representative group of instructor pilots should be tested to identify trends.

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