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Predicting Health Effects of Electromagnetic Pollution in Algeria Using Fuzzy Logic

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Abstract

Many countries have developed limits for public exposure values. However, there are no Algerian recommendations or laws governing electromagnetic pollution. This work aims to assess the exposure by measuring the electromagnetic field. Then, these results are compared with literature studies that treat the effects of electromagnetic field on public health. Because these reactions are characterized by uncertainty and imprecision, we found it useful to analyze these data by fuzzy logic. Fuzzy logic is perfectly appropriate in our case in which a fuzzy algorithm is proposed to predict the health effects on exposed subjects from the input variables.

Keywords

Electromagnetic Pollution, Waves, Fuzzy Logic

1. Introduction

Environmental exposure generated by human activity has significantly increased electromagnetic fields (EMF) (Consales and *al*; 2012). Hundreds of studies have shown that EMF has biological and sometimes pathological effects (Touitou, 2004). Many research studies have identified biological effects far below the thermally based exposure limits, such as increased permeability of the blood-brain barrier in the head, deleterious effects on sperm, double strand breaks in DNA, and stress gene activation indicating an exposure to a toxin. Other studies have pointed at an increasing risk of acoustic neuroma, brain, salivary gland tumors and eye cancer(Perrin and *al*; 2010). Additional studies have reported increased risk of Alzheimer, Parkinson's disease, amyotrophic lateral sclerosis and epilepsy (Sobel and *al*; 1995, Chengxuan and *al*; 2004, Qiu and *al*; 2004, Hallberg and *al*; 2011). The problem of electromagnetic fields is to determine the threshold of harmfulness and the size of the harmful sphere around the source of pollution. This topic is still under debate. For this reason, many countries have developed limits for public exposure; these values are based on the work of the International Commission for the Protection against Non-Ionizing Radiation Protection (ICNIRP) (Séné, 2010).

In this context the present work is part of research whose main goal is to indicate health effects of electromagnetic pollution. As the measured values are characterized by imprecision given the physical nature of wave propagation in different environments, we found it useful to use a numerical analysis using the technique of artificial intelligence, including the principles of fuzzy logic, connecting the values of the measured fields their effects on the body to provide pollution.

2. Methods and Materials

2.1. Measurements of Electromagnetic Field Induction

The first step in this work is to measure the EMF of different pollution sources using a Teslameter (Figure 1). Then, the values obtained were compared with the limit values of the International Commission against Non Ionizing Radiation Protection (ICNIRP).

EMF health effects are related with exposure levels.

Therefore to assess our own level of exposure, the use of measuring devices is important. Several authors have shown that the electric field and magnetic field are well correlated and could be enough to measure the magnetic field to have a good idea of human exposure.

Fig. 1. *Chauvin Arnoux CA40 teslameter.*

Induction of magnetic field was measured using a wide-range measuring device with a measurement range of 0-2000 micro Tesla (µT) (Chauvin Arnoux CA40 teslameter -gauss meter-).

EMF was measured at different distances to each pollutant (0, 10 20, 30, 40, 50, 100, 200 and 300 cm respectively).

For Wi-Fi, mobile phones and base stations averages were calculated.

For appliances, the values obtained are remote, so we selected only the maximum exposure values.

The values obtained were compared with the standards of the International Commission against Non-Ionizing Radiation (ICNIRP).

EMF exposure limits have been established since the 1980s, including the ICNIRP, which is a non-governmental organization recognized by the WHO and consists of doctors and specialists of electromagnetic field (WHO, 2010).

2.2. Data Processing

Hundreds of studies on the health effects of EMF have very mixed results. These forces us to use an analytical technique based on the principles of artificial intelligence, including the principles of fuzzy logic.

2.2.1. Inputs

The structure of the block diagram of our analysis system consists of seven fuzzy inputs (figure 2). These inputs are inspired from epidemiological studies that aim to find the link between exposure to EMF on one hand and harmful biological effects on the other.

Nevertheless, most studies have mainly lack of data regarding the magnetic density, distance from pollutant, duration and type of exposure. So we used only the most accurate studies.

EM Induction values are measuring with teslameter from many sources of pollution.

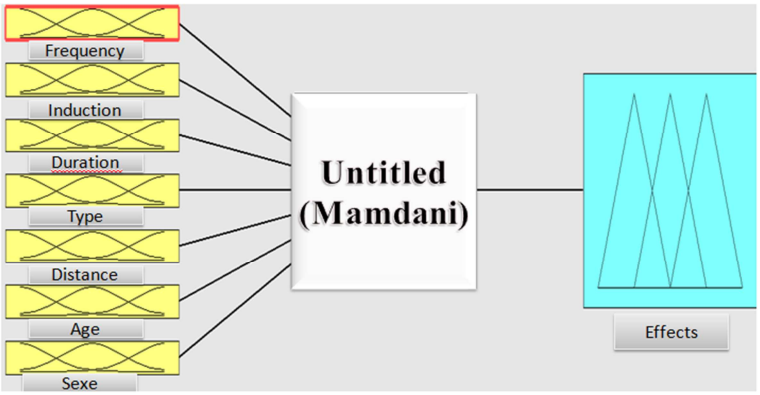

Fig. 2. *Structure of fuzzy system with seven inputs and one output.*

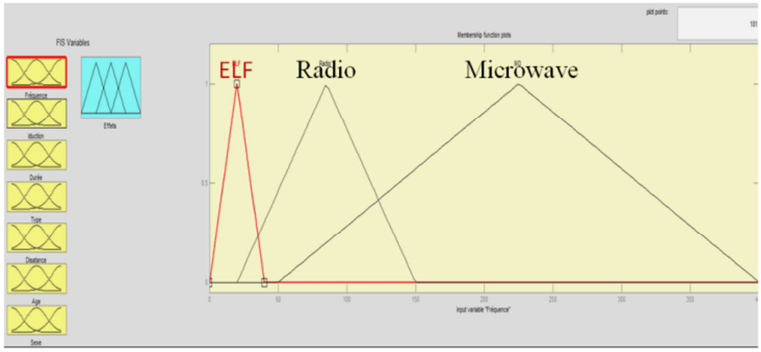

Fig. 3. *Fuzzification of the "frequency" variable in three fuzzy intervals.*

A. Fuzzification of the input variable "Frequency"

Since the effect of the input parameter "Frequency" on health is unclear, it is considered as fuzzy variable. Three fuzzy intervals are available and membership functions of triangular type that defines the language variable:

"ELF" Extremely Low Frequencies as corresponding to a frequency lower than 40 Hz.

"Radio" as corresponding to a frequency f (20 Hz $<f<$1.5 GHz).

"Microwave" as (0.5GHz $<f<$400 GHz) (Figure 3).

The effect of ionizing radiation on health is well known. For this reason, these radiations were excluded from this study.

B. Fuzzification of the input variable "Magnetic Induction"

Following the same principle of the fuzzification of frequency, three fuzzy intervals and membership functions of triangular or trapezoidal type were selected by defining:

"Light" as corresponding to a range between (0 and 0.15 µT).

"Average" as corresponding to a range of (0.05 and 0.45 µT).

"Strong" as corresponding to a value greater than 0.35 µT (figure 3).

C. Fuzzification of the input variable "Exposure per Day"

Two fuzzy intervals and membership functions of triangular and trapezoidal type are proposed to represent the average exposure levels per day:

"Small" as corresponding to a range between (0 and 65 minutes / day).

"Great" as corresponding to an average of over 55 minutes/ day.

D. Fuzzification of the input variable "Exposure Type"

Two fuzzy intervals and membership functions trapezoidal type are proposed to represent the levels of types of exposure:

"Acute" as corresponding to a range between (0 and 5 years).

"Chronic" as corresponding to a period of more than 4 years.

E. Fuzzification of the input variable "Distance from the source"

Three fuzzy intervals were chosen and membership functions trapezoidal type of this variable:

-"Short" as corresponding to a range between 0 to 35 cm.

"Intermediate" as corresponding to a range between 25 and 105 cm.

"Long" if the distance is greater than 95 cm.

F. Fuzzification of the input variable "Age"

Three fuzzy intervals (tracks) are available and membership of triangular type defining linguistic variable functions:

"Young" as corresponding to a range of (-0.25 and 25 years).

"Adult" as corresponding to a range between 20 and 45 years.

"Old" beyond (40 years) (Bouharati and *al*; 2012).

Several studies have demonstrated the effect of EMF on the fetus - during pregnancy- (Di Carlo and *al*; 2002, Batellier and *al*; 2008). So, a fourth track has been added:

"Fetus" as corresponding to a range between (-1 and 0 year).

G. Fuzzification of the input variable "Sex"

The variable "Sex" is not fuzzified. We assigned (1 and 2) corresponding to the male or female gender (Bouharati and *al*; 2012).

Male [1]

Female [2].

2.2.2. Output Variable "Effects of EMF"

The output variables are fuzzified into three linguistic variables:

"No effect" as corresponding to a range between (0 and 2).

"Biological effect" as corresponding to a range between (1 and 4).

"Pathological effect" as corresponding to a range between (3 and 5).

2.2.3. Inference Rules

Through the manipulation of a large number of rules, we will be able to pass judgment on an issue relating to a specific area. In our case, the frequency, magnetic induction, duration and type of exposure, distance, age and sex are combined with the effects of EMFs.

3. Results and Discussion

By comparing the measured values with the EMF limit values of the ICNIRP, we can notice that:

The EMF of mobile phones and their base stations far beyond the limits.

The EMF of few devices beyond the limits (drummers, UPS, hair dryers, electric shavers and microwave ovens).

However, new studies have proven that the current standards are inadequate because they do not absolutely guarantee the protection of individual health and how to define those that should be adopted so as to appear no disease

4. Application Example

4.1. Hypothesis 01 (Figure 4)

If:

Frequency is 322 GHz

Magnetic induction is0.484 µT

Exposure time is 87.6 min

Type of exposure is 9.68

The distance to the source of the field and is 19.3 cm

Age is 17 years

Sex is 1.97 (female)

So the effect is 4 *(pathological)*

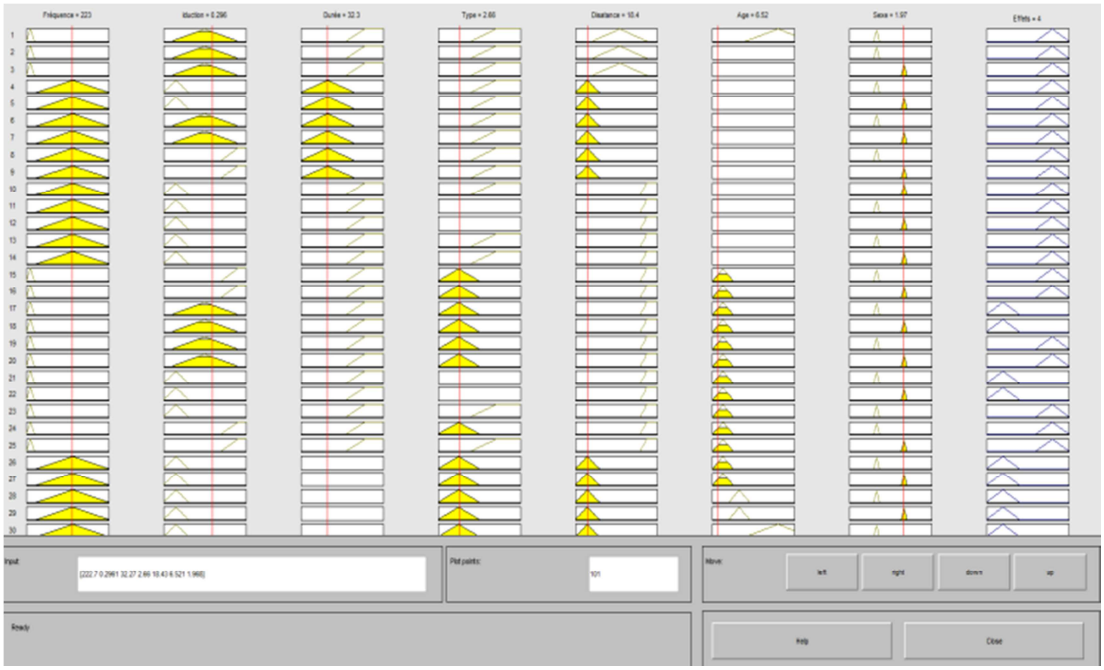

Fig. 4. *Application Example (hypothesis 01) where we can randomly assign values to input instantly read the pathological effect.*

4.2. Hypothesis 02 (Figure 5)

If:
Frequency is 322 GHz
Magnetic induction is 0.484 µT
Exposure time is 87.6 min
Type of exposure is 9.68
The distance to the source of the field and is 19.3 cm
Age is 25 years
Sex is 1.97 (female)
So, the effect is 2.5 *(biological)*

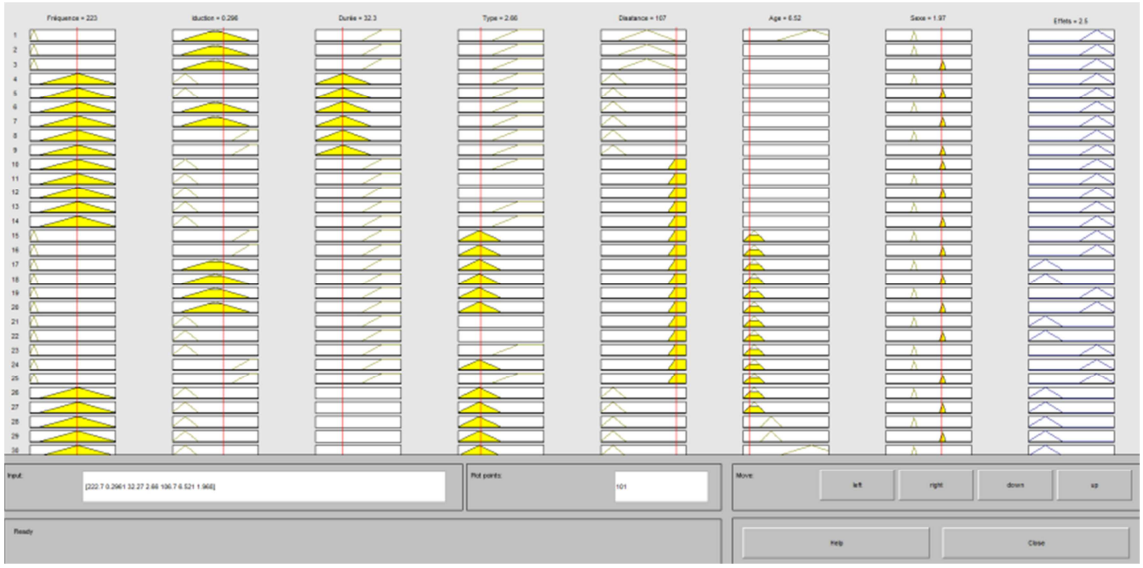

Fig. 5. *Application Example (hypothesis 02) where we can randomly assign values to input instantly read the biological effect.*

5. Conclusion

The problem of electromagnetic fields is to determine the threshold of harmfulness and the size of the harmful sphere surrounding the source of pollution.

To better understand the effects of these fields, we try to use an analytical technique based on the principles of fuzzy logic. Inspiring inputs and the output from recent epidemiological studies, our system is able itself to predict the health effects of EMF.

However, there are a very limited number of studies. Also, the studies present sometimes mixed results. So, other studies are needed to understand electromagnetic health effects.

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