Android application for monitoring and diagnosing air quality

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Abstract – **Air pollution is a major factor in developing
health problems and its monitoring is essential in
preventing them. The proposed application (AirAI) aims
to provide information to people about the environment,
respectively about the quality of the air they breathe in
daily life. Through it, the concentration of each air
pollutant, the corresponding index and the evolution in
time can be identified. The people may also receive
warning messages if a pollutant is about to exceed the
allowable threshold or alert messages if the threshold
has been exceeded and human health may be affected.
Once warned, the application also presents a series of
instructions that people can follow so as not to endanger
their health. The application also uses artificial
intelligence techniques, as it also presents a module that
contains an expert system (knowledge base and
inference engine) for establishing the general quality
index of an air monitoring station and for issuing the
corresponding warning messages. The developed expert
system calculates the general index of an area gradually:
initially it takes over all the concentrations of the
pollutants, allocates for each pollutant a particular
index, depending on its concentration.**

*Keywords-air pollution, pollutants, artificial
intelligence, expert systems, inference engine, monitoring*

I. INTRODUCTION

Air quality is an area that links the environment to
the industrial environment. Usually, air quality is
described through six indices: good, acceptable,
moderate, bad, very bad and critical. The connection
between the environment and the industrial
environment is motivated by the increase of air
pollution with the industrial development. Several
studies have shown that the evolution / expansion of
the industry has led to increased pollution, an action
that has led to climate effects and disruptions in the
carbon, oxygen and sulphur cycle. These effects
produce negative, irreversible changes on the planet,
affecting both plants, animals and humans [1], [2].

The usual measured parameters are represented by
air pollutants such as: PM_{10}, SO_2, NO_2, NO, NO_x, Ni,
Toluene, Benzene, Cd, As, CO, O-Xylene, M-Xylene,
P-Xylene and Ethylbenzene. The indices for each
parameter were established according to current
legislation specific to the measured area that specify
the limit of pollutants in relation to human health and
the environment and of particular interest is the case of
a smart city [3]. The air pollutants specific intervals
presented in table I were established using the

pollutant specific index presented on the national air
quality monitoring network AirQuality (for PM_{10},
NO_2, SO_2 and NO_x pollutants) [4].

For Benzene and CO pollutants were used the data
supplied by AirQuality network and the tolerance
intervals presented in law no. 104 from June 15, 2011
[4], [5]. The NO intervals were established
considering the intervals for NO_x and NO_2 pollutants
[4].

The O-Xylene, P-Xylene, M-Xylene, Toluene and
Ethyl-benzene intervals were established using the
xylenes, ethylbenzenes and toluene assessment reports
from Alberta Environment organisation (Department
of Environmental Protection), from Massachusetts [6],
[7], [8]. Finally, the Ni, As and Cd intervals were
established using the air quality report in Europe of the
European Environment Agency and also the normative
provided by law no. 104 from June 15, 2011 [5], [9].

TABLE I.   SPECIFIC INTERVALS FOR POLLUTANTS

Pollutant [µg/m³]	Intervals					
	good	accept able	moder ate	bad	very bad	critic al
PM_{10}	[0,20)	[20, 40)	[40, 50)	[50, 100)	[100, 150)	≥150
O-Xylene	[0,10)	[10, 20)	[20, 30)	[30, 40)	[40, 60)	≥60
P-Xylene	[0,10)	[10, 20)	[20, 30)	[30, 40)	[40, 60)	≥60
M-Xylene	[0,10)	[10, 20)	[20, 30)	[30, 40)	[40, 60)	≥60
Ni	[0,10)	[10, 15)	[15, 20)	[20, 25)	[25, 30)	≥30
As	[0, 2)	[2, 4)	[4, 6)	[6, 8)	[8, 10)	≥10
Cd	[0, 2)	[2, 4)	[4, 5)	[5, 7)	[7, 9)	≥9
NO	[0,50)	[50, 100)	[100, 200)	[200, 300)	[300, 400)	≥400
NO_2	[0,40)	[40, 90)	[90, 120)	[120, 230)	[230, 340)	≥340
NOx	[0,50)	[50, 100)	[100, 200)	[200, 300)	[300, 400)	≥400
Toluene	[0,80)	[80, 200)	[200, 250)	[250, 300)	[300, 400)	≥400
Ethyl-benzene	[0,50)	[50, 100)	[100, 150)	[150, 200)	[200, 300)	≥300
Benzene	[0,2)	[2, 4)	[4, 5)	[5,10)	[10, 13)	≥13
CO	[0, 2)	[2, 5)	[5, 10)	[10, 16)	[16, 20)	≥20
SO_2	[0, 100)	[100, 200)	[200, 350)	[350, 500)	[500, 750)	≥750

II. STATE OF THE ART

Monitoring and diagnosing air quality have become an important topic over time, which is why systems have been developed to perform these functions both nationally and internationally.

In the literature are presented a series of systems dedicated to air quality monitoring using AI (artificial intelligence) techniques, such as: knowledge-based systems, intelligent agents, fuzzy logic, data mining, artificial neural networks (ANN's), etc.

In the following there are presented specific features of the developed systems.

A. ROKIDAIR

A national example can be given by the ROKidAir project, which measures the impact of air pollutants on one of the most vulnerable social categories, namely on children's health. The main purpose of the project is to warn people when air pollution episodes occur, especially in the case of particulate matter with a diameter less than 2.5 microns (PM2.5), due to the causality link between air pollution and asthma on children's health [10].

This project uses artificial intelligence techniques for monitoring and diagnosing air quality such as: knowledge-based reasoning technique (expert systems).

A knowledge-based system, INTELLEnvQ-Air, is used to analyze the effects of particulate matter on human health, whose knowledge base is composed of heuristic rules under IF-THEN form. The knowledge-based system is implemented using an expert systems generator, namely VP-Expert, that has a knowledge base component (PM2.5-KBS-1) and an inference engine that realizes the chain of reasoning in order to obtain a result. Within the knowledge-based system there are three main groups of rules: rules that establish the common air quality index, rules that characterize the impact of air pollution on human health by evaluating the pollutant PM2.5 and rules that add to this evaluation other pollutants such as oxides, sulfates, carbon monoxide, ozone, meteorological parameters (temperature, wind speed, humidity), social aspects (eg age, status) and medical aspects [11].

The ROKidAir project analyzes other toxic substances that are related to or influence the concentrations of particulate matter. A case study carried out within this project in 2013 and 2014 in the case of monitored benzene concentrations in the city of Ploiesti, PH-2 station, through the GIS geoportal, shows that there was an increase in the maximum value from 2013 to 2014.

Given that benzene is a substance with a very high degree of toxicity, causing serious health problems in people such as leukemia, cancer, it is found that this pollutant requires a very great attention within the city of Ploiesti, being necessary concrete actions to reduce the exposure of the population to this substance [12].

The ROKidAir project is of great importance in everyday society, due to the fact that it generates personalized information to people, taking into account both air pollutants, the environment, social aspects and aspects related to people's health.

B. Copernicus

Copernicus is a program in the European Union, which has as main goal the development of Information services, based especially on the Earth Observation satellite and in-situ data [13].

Within this program, there is the system that deals with air pollution monitoring, CAMS - Computer Atmosphere Monitoring Service. It informs people about the level of concentrations of air pollutants in Europe. The measurements are made with the help of satellites and other observation instruments, in collaboration with computer models, to track the accumulation and action of pollutants in the context of the planet. To encompass a record of air pollution over time, CAMS uses a method called regional scientific reanalysis.

The artificial intelligence techniques with which CAMS manages to fulfill its functionalities are machine learning and data mining (DM).

Through machine learning techniques, computers automatically learn to process entire data sets. Along with these techniques, the 'deep learning' method is implemented, including the technique of artificial neural networks used in order to identify certain patterns and make the best possible decisions regarding the data sets they have to process. A key aspect pursued is the ability to learn from experience, like humans. Thus, with the help of the machine learning technique, respectively deep learning, computers can progressively improve their data processing and can generate predictions based on them [14].

The pollutants considered are: ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter with a diameter less than ten microns, respectively 2.5 microns, smoke particles, grass pollen, ragweed pollen, tree pollen, dust, etc.

An interesting aspect of CAMS is that it covers a large part of the possible pollutants in Europe, including substances that can cause allergies in humans (namely the pollen, which annually affects a large part of the population). In correlation with low temperature and rain, the pollen load in the atmosphere decreases, and the symptoms of allergies disappear. Thus, by informing people about the amount of pollen in the atmosphere and climatic conditions, they can prevent the appearance of mild or severe symptoms.

Copernicus has the advantage of displaying, through an interactive map, the levels of air pollutants in real time. In Fig. 1 it is presented the pollen levels of birch trees in Europe on April 19, year 2021.
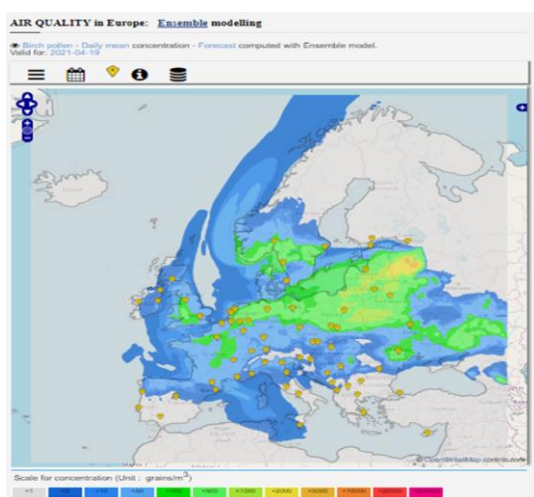
Figure 1.   Birch pollen in Europe on 19.04.2021 [13], [14].

C.   The Weather Channel

The Weather Channel is available both as a web application and as a mobile application. This type of application presents like the CAMS system within the COPERNICUS program, information regarding the air quality monitoring from different areas, being included also the monitoring of several types of pollen.

The Weather Channel application uses the technique of data mining with the help of which it makes predictions regarding the risks of the appearance of the symptoms caused by allergies about 15 days before. This is achieved by training a model to combine multiple weather attributes with environmental data and anonymous health data, providing an assessment of the risk of symptoms [15].

In addition to the results provided in terms of air pollution, this application offers the evolution over time of allergens and tips for allergy management [16].

D.   Calitateaer.ro

The calitate-aer.ro website is a web application that monitors real-time air pollutants in Romania. It establishes for each station an index of quality both hourly and daily for each station based on the concentrations of air pollutants. Along with this index, details such as information about pollutants, the evolution over time of each pollutant, respectively its hourly values can be viewed.

The AI techniques that underlie this site are: techniques based on intelligent agents, through a multi-agent system, composed of monitoring stations, which have as common goal the collection of sufficient and accurate data to be validated and techniques based on fuzzy logic, through which some linguistic terms are assigned (quality indices: good, acceptable, moderate, bad, very bad, critical) to intervals corresponding to the limits related to the concentrations of air pollutants regarding human health and environmental health.

Pollutants are evaluated such as: PM_{10} and PM2.5 particulate matter, ozone, toluene, benzene, oxides, toxic metals (lead, cadmium, arsenic, mercury), polycyclic aromatic hydrocarbons and carbon monoxide. These pollutants are evaluated taking into account law no. 104 of June 15, 2011, issued by the Romanian Parliament [4], [5].

E.   SBC Environment

SBC Environment is a system developed for monitoring environmental elements such as water, air, soil with the aim of solving current issues related to environmental protection. The monitoring of three elements is performed by means of some modules, respectively: for air the system based on SBC-AIR knowledge is used, for water the system based on SBC-WATER knowledge will be used, and for soil the SBC-SOIL system.

The SBC-AIR module, represented by the SBC-AIR knowledge-based system, proposes the evaluation of the air quality index at a given time with the help of the monitored concentrations at intervals of one hour or 15 minutes. Among the parameters analyzed by this system are: ozone, nitrogen dioxide, sulfur dioxide and particulate meters with a diameter less than 10 microns (PM_{10}). Thus, in order to display an air quality index, the 4 values of the pollutant concentrations are introduced. The system will provide the code through a client-server application to users in the monitored area [1].

F.   AirQMas

AirQMas is a multi-agent system, designed to analyze air quality for different stations in Romania. This system takes the data from the national air monitoring network (namely calitateaer.ro web site) and depending on the concentration of each pollutant, allocates an index according to the norms and standards for air quality in the country. The index can take one of the values: excellent, very good, good, medium, bad, very bad. Among the pollutants analyzed are: sulfur dioxide, particulate matter, nitrogen dioxide, nitrogen monoxide, carbon monoxide and ozone. The AI techniques used in building the system are intelligent agents based and data mining.

The multi-agent system is composed of two main types of agents: environmental agents, represented by the MAS1 multi-agent system and weather agents, represented by the MAS2 multi-agent system. The agents communicate with each other, in order to obtain the most correct results, which render the real situation of the air pollution level in an efficient time. Weather agents provide information on weather conditions, such as: temperature, humidity, wind speed, which can affect the degree of air pollution, and environmental agents monitor pollutant concentrations and perform an analysis based on them.

The data mining technique is used by environmental agencies to extract rules from databases, regarding the measured concentrations of certain pollutants in a region, in a given period of time. Through this technique, environmental agents learn to determine what type of pollutant influences air quality

to the greatest extent in the area in which it is distributed [17].

III. DESIGN AND IMPLEMENTATION OF THE APPLICATION FOR MONITORING AND DIAGNOSING AIR QUALITY

In AirAI Android application development was used a set of programming languages and technologies (PHP, MySQL, JavaScript, MIT App Inventor) and AI techniques, such as knowledge based systems/expert systems and the model of certainty coefficients (CNF). The proposed application AirAI is composed of 4 main modules: the design module, the data extraction module from the database (DEM), the module for displaying the evolution of pollutant concentrations over time (MEPC) and the expert system (ES) module.

The data extraction module (DEM) from the database takes over the values related to the hourly concentrations in case of the following parameters: SO_2, NO_x, NO_2, NO, respectively taking over the annual concentration of benzene, cadmium, arsenic and nickel, taking over the concentration for 24 hours in the case of PM_{10} and ethylbenzene and taking over the concentration for 8 hours in the case of CO, toluene, M-Xylene, P-Xylene and O-Xylene. The concentration for 8 hours is measured between 17:00 - 01:00 and 16:00 - 24:00. For the 2 intervals, the average concentrations are calculated. The concentration that will be taken into account will be the maximum average between the 2 calculated averages. This value will be allocated to the day following the measurements. The 24-hour concentration is obtained by calculating the arithmetic mean of the concentrations in the last 24 hours. The annual concentration in the case of benzene, cadmium, arsenic and nickel is represented by the average values from the beginning of the year until the current moment.
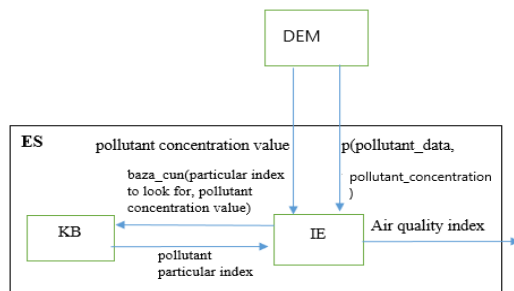

Figure 2. Expert system structure: DEM – data extraction module, KB – knowledge base, IE – inference engine.

The PHP language was used to implement the data extraction module (DEM). The module is represented by a function called *p (function p (pollutant_data, pollutant_concentration)*. This function takes over the concentration of a pollutant from the database, taking into account the current date and the date on which the pollutant was monitored by performing queries using the database management system, *MySQL* and by applying calculations for pollutants analyzed on 8 hours, 24 hours, respectively for 1 year.

The ES module consists of 2 submodules: the knowledge base (KB) and the inference engine (IE) (Fig. 2).

As seen in Fig. 2, the expert system takes the concentration for each monitored pollutant and displays based on all pollutants an index of air quality in the area where the air quality is analyzed.

The ES knowledge base is composed of rules that establish the classification of air pollutants in certain intervals and the allocation of specific indices (good, acceptable, moderate, bad, very bad, critical) to each monitored pollutant. It was implemented using the PHP language and is represented by a function, called *know_base* (*function know_base ($x, $p)*), with 2 input parameters: the name of the specific index sought for a pollutant (x) and the value of the pollutant concentration (p). At the output, the knowledge base will provide the specific index searched for the pollutant, whose name and concentration have been entered as input parameters (x, p).

The rules in the knowledge base were built on the basis of the intervals from table I, intervals taken over taking into account national laws and other information sources (such as Alberta Environment reports, articles from the European Environment Agency) specifying the limit of pollutants in relation to human health and the environment [4], [5], [6], [7], [8], [9].

The rule base is composed of 15 main rules, which have in their composition 6 sub-rules each. The main rules check the name of the specific index to be searched, and the sub-rules take the pollutant concentration, place it in a certain interval and assign to a variable the value of specific index of the pollutant searched. It is important to mention that if a main rule is not met, the sub-rules will not be executed either. Once the specific index of each pollutant is extracted from the knowledge base, the inference engine will chain the results in other rules for establishing the general air quality index for the entire station, taking into account all the analyzed air pollutants. An example of a KB rule composed of subrules is:

if(x=="index_PM10"){

    if (p>=0 && p<20)

      {$index_PM10$="good";}

    else if (p>=20 && p<40)

      {$index_PM10$="acceptable";}

    else if (p>=40 && p<50)

      {$index_PM10$="moderate";}

    else if (p>=50 && p<100)

      {$index_PM10$="bad";}

    else if (p>=100 && p<150)

      {$index_PM10$="very_bad";}

    else if (p>=150)

      {$index_PM10$="critical";}

return $*index_PM10*;}

The ES inference engine is implemented in the PHP language, via the function without parameters *engine_inf (function engine_inf())*. It is the control center of the system, because it calls all the modules (DEM for data collection, knowledge base for extracting the specific index of each air pollutant) and further links the results obtained in other rules. To determine the coefficients of each specific index, it uses a function called *index_value* with a single parameter, namely the value of the specific index (*function index_value($specific_index)*), function presented below:

function index_value(*$specific_index*){

if (*$specific_index*=="good") return 1;

else if (*$specific_index* =="acceptable") return 2;

else if (*$specific_index* =="moderate") return 3;

else if (*$specific_index* =="bad") return 4;

else if (*$specific_index* =="very_bad") return 5;

else if (*$specific_index* =="critical") return 6;}

This stores all coefficients in a vector (*$vector*) and calculates the maximum coefficient. For the calculation of the final/general index, the value of the specific index with maximum coefficient is taken into account (*$station_index=max($vector)*). A selection of the PHP source code associated with the developed *engine_inf*() function is presented below:

function engine_inf()

{*$PM10*=p("Data_PM10","PM10");

$index_PM10=know_base ("index_PM10", $PM10);

$station_index*=max (*$vector);

if (*$station_index* ==1) echo "Quality index: good";

else if (*$station_index*==2) echo "Quality index = acceptable";

else if (*$station_index*==3) echo "Quality index: moderate";

else if (*$station_index*==4) echo "Quality index: moderate";

else if (*$station_index*==5) echo "Quality index: very_bad";

else if (*$station_index*==6) echo "Quality index: critical";

if (*$index_PM10*=="very_bad"){

echo " Warning! The PM10 index is about to exceed the allowable threshold.";

echo "\n Close the doors and windows. ";

echo "\n Tell the people you know to apply preventive measures.";}

Thus, it is observed that initially it is checked if the specific index of the PM$_{10}$ pollutant is searched. If so, its concentration will be within a certain range and will return, based on the range found, the value of the particular PM$_{10}$ index, $*index_PM10*.

In order to display the warning / alert messages, the results extracted from the knowledge base are linked, respectively specific indices in other 30 rules from which 2 rules will be presented:

if (*$index_NOx* == "very_bad") {

echo "Warning! The oxide index is about to exceed the permissible threshold.";

echo " n Close doors and windows.";

echo "Attention! Oxides also affect vegetation!";

echo "\n Tell your relatives to apply preventive measures.";}

if (*$index_CO* == "critical") {

echo "Alert! The concentration of carbon monoxide in the air has exceeded the permissible threshold. Please take safety precautions! \n";

echo "Avoid industrial areas in the city!";

echo "Make sure you have the windows closed! \n";}

Similarly, the specific indices for SO$_2$, NO$_2$, NO, NO$_x$, M-Xylene, P-Xylene, O-Xylene, Cd, As, CO, Benzene, Toluene, Ethylbenzene, Ni pollutants are calculated. Thus, it is observed that for each pollutant a specific index is calculated. This specific index is searched by name in the knowledge base as a goal and its value is calculated based on the pollutant concentration.

The main purpose of the inference engine is to establish the quality index (general index) of the entire monitored area using the specific index associated with each pollutant. It appeals to the knowledge base and links the results extracted in other rules to achieve its goal. In order to obtain the general index of the station (*$station_index*), IE goes through the following stages:

• takes over the concentration of each pollutant with the help of the data collection module;

• calls the knowledge base for each pollutant taken over to establish the specific index based on the concentration;

• once the specific indices are calculated for all air pollutants, a coefficient from 1 to 6 will be allocated for each value of the specific index, 1 for specific_index = "good", 2 for specific_index = "acceptable", 3 for specific_index = "moderate", 4 for specific_index = "bad", 5 for specific_index = "very_bad" and 6 for specific_index = "critical"; based on these coefficients, the specific index with maximum coefficient will be searched;

• depending on the value of the maximum coefficient, the general index of the area in which the monitoring is made will be established, with the help of the previous stage of allocating the coefficients; for example, if the value 3 is obtained as the maximum coefficient, the specific index will have the value "moderate".

In addition to the calculation of the general index, IE checks for each pollutant if the specific index has one of the values "very_bad" or "critical". Within the

"very bad" value, it will display a warning message to people, informing them that the pollutant is about to exceed the allowed threshold and proposes some preventive measures, so as not to endanger their health. If it meets the "critical" value, it will display an alert message, in which it will communicate to people that a certain pollutant has exceeded the allowed threshold, and their health may be endangered. Along with the alert message there are received and tips to prevent harm to human health and the environment.

The AirAI interface module (Fig. 3) was designed using MIT App Inventor [18]. Thus, the application interface is user-friendly, consisting of buttons and display elements such as graphics and suggestive images. Warning and alert messages are also displayed with the help of the MIT App Inventor, which cooperates with PHP scripts to perform the functionalities as efficiently as possible. The MIT App Inventor addresses the following tasks: initializing an interface consistent with script results, displaying informational messages about how to use the application, and displaying the evolution of concentrations over time for each pollutant.
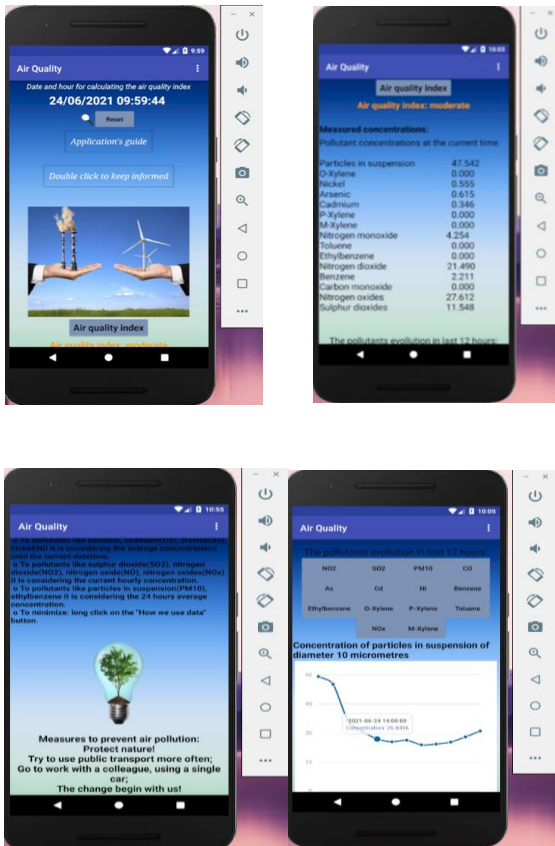

Figure 3. User interface of the designed app.

The application offers total transparency regarding the data taken and analyzed, both through graphs from which you can see the concentrations of each pollutant in the last 12 hours, and through an information section, operated by the "How to use data" button. It shows how the concentrations of each pollutant are analyzed so that users can better understand why certain indices appear at different times (Fig. 3).

A. Simulation results

In tables II, III and IV there is presented a selection of the AirAI simulation results.

TABLE II.   SIMULATION RESULTS

Pollutant [μg/m³]	Simulation no. 1	Simulation no.2	Simulation no. 3
PM_{10}	26.604	47.056	25.933
O-Xylene	0	0	0
Ni	0.552	0.555	0.553
As	0.612	0.615	0.612
Cd	0.344	0.346	0.344
P-Xylene	0	0	0
M-Xylene	0	0	0
NO	7.274	3.696	4.622
Toluene	0	0	0
Ethyl-benzene	0	0	0
NO_2	28.641	15.476	150
Benzene	2.199	2.211	2.199
CO	0	0	0
NOx	39.394	20.744	39.727
SO_2	5.539	10.355	5.168

TABLE III.   SIMULATION RESULTS

Pollutant [μg/m³]	Simulation no. 4	Simulation no.5
PM_{10}	25.356	24.782
O-Xylene	0	0
Ni	0.553	0.553
As	0.612	0.613
Cd	0.344	0.344
P-Xylene	0	0
M-Xylene	0	0
NO	9.211	5.504
Toluene	0	0
Ethyl-benzene	0	0
NO_2	50.726	43.517
Benzene	2.199	2.199
CO	0	125.0
NOx	64.448	51.556
SO_2	500	4.457

TABLE IV.   SIMULATION RESULTS

No. simulation	Dates	Quality Index IE	Notifications
1	25.06.2021 13:00:00	acceptable	-
2	24.06.2021 23:00:00	moderate	-
3	25.06.2021 14:00:00	bad	-
4	25.06.2021 15:00:00	very bad	warning
5	25.06.2021 17:00:00	critical	alerts

In case 1 (simulation no. 1) it is observed that the provided result is acceptable, written in a shade of green, together with a suggestive image. Along with this result, the user can see the real-time evolution of any air pollutant, an example in this case being the evolution of Arsenic (Fig. 4).
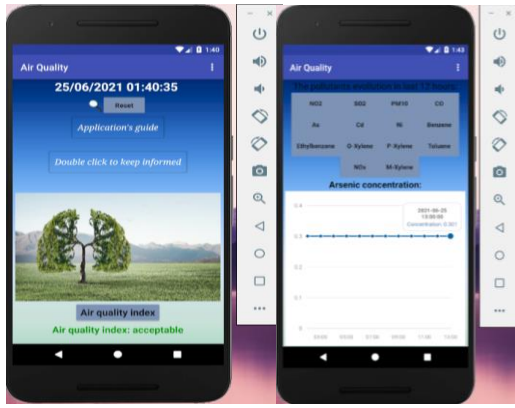
Figure 4.   User interface for case 1

In case 2 (simulation no. 2) the developed expert system inference engine returns a moderate result, framing according to the intervals from table I and values from table II, each pollutant concentration in the corresponding interval (Fig. 5).
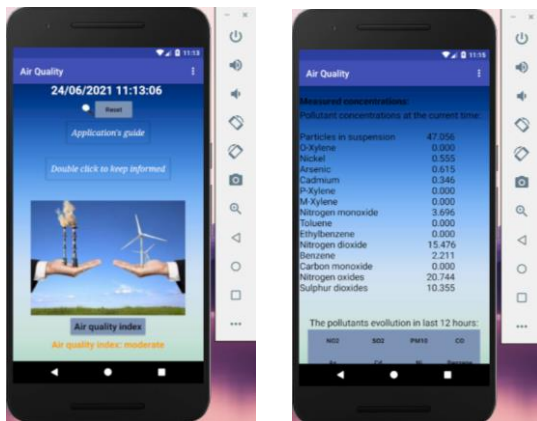

Figure 5.   User interface for case 2

In case 3 (simulation no. 3), the value of nitrogen dioxide NO2 is updated, from 15.476 µg/m³ to 150 µg/m³. The update is made in real time, observing in a short time the change of the air quality index in "bad". Also, the real-time behavior of the application is indicated by the real time update of the NO_2 measured value, respectively 150 µg/m³ (Fig. 6).
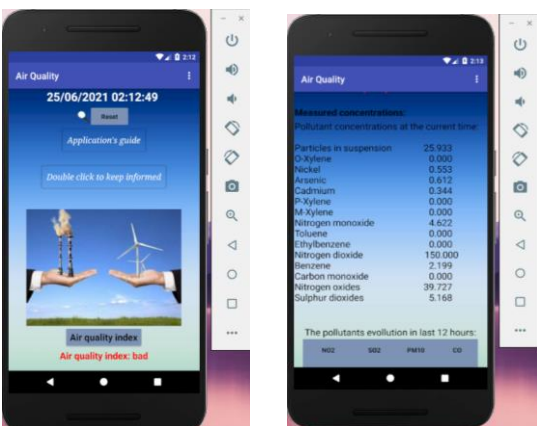
Figure 6.   User interface for case 3

In case 4 (simulation no. 4) the SO_2 value changes to see what changes occur. Thus, the index becomes "very bad", written in a shade of red, along with an image that highlights the severity of the pollution level. In addition to displaying the air quality index, users receive a warning notification, informing them of the possibility of exceeding the allowable threshold in the case of SO_2 pollutant and some measures they can take so as to be as little affected as possible. Similar to case 3, and in case 4 the reaction of the application to the changes brought in real time is observed (Fig. 7).
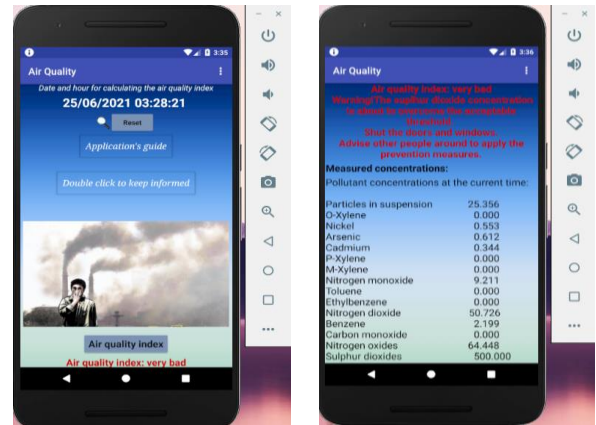

Figure 7.   User interface for case 4

In case 5 (simulation no. 5), the CO pollutant analysis is performed at 8-hour intervals (according normative): an average of concentrations is performed between 16:00-00:00 and another average between 17:00-01: 00. So, the CO maximum average is taken, respectively 125 µg/m³, which according to the intervals presented in table I, corresponds to the critical index, index that will become the general air quality index (Fig. 8).
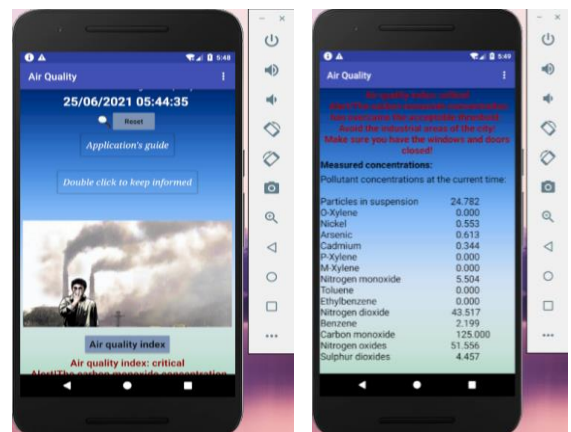

Figure 8.   User interface for case 5

The database of the application is made in MySQL and presents a number of 5567 records representing the values measured at the time ranges of the monitored parameters (PM$_{10}$, O-Xylene, Ni, As, Cd, P-Xylene, NO, Toluene, Ethylbenzene, M-Xylene, NO$_2$, Benzene, CO, NOx and SO$_2$). The pollutant values from database are real data, measured in 2014 through the RO0175A monitoring station, data used for testing the proposed application. These data were taken from

the Romania's Government website, the open data section for the entire year [19]. A selection of records is presented in Fig. 9.

Figure 9.   A quick view of database

The simulation was performed using the Android Studio program, the AVD manager module, through which the Nexus 6 API 25 emulator, Android version 7.1.1 was created for this purpose.

CONCLUSION

The usage of AI techniques, respectively of knowledge-based systems/expert systems in solving environmental problems, such as the air pollution problem, proves its usefulness through various applications that can be developed and used for monitoring, diagnosis and air quality control. The authors main contributions are: the development of a warning/alert system (by developing rules for implementing the warnings / alerts system) for people real time information regarding the air pollutants admissible limits exceeding (the establishing an air quality index based on each pollutant concentration measured value), the development of a module that contains an expert system (the KB and also the IE system development) for the efficient supply of correct AirAI results. Moreover, the real-time delivery of the AirAI results was achieved and also was developed a user-friendly, intuitive and dynamic interface (using MIT App Inventor development environment) for the proposed Android application. A major advantage of the AirAI developed application is the real-time delivery of results and also the fact that it offers transparency to the users regarding the analyzed data, thus helping them to better understand why they receive a warning or alert message. The application fulfills its main purpose, that of informing people about an important problem in today's society, air pollution. Thus, once informed, people can take measures in time so that their health is not affected, respectively they can take measures to prevent pollution. The application can be improved to address all categories of users (to include a module that informs people in audio format). Adding information for each pollutant can lead to better results, so that people know how toxic it is and how to avoid its effects.

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