AIR POLLUTION ASSESSMENT USING HIERARCHICAL FUZZY INFERENCE SYSTEMS

Petr Hájek, Vladimír Olej
Institute of System Engineering and Informatics, Faculty of Economics and Administration, University of Pardubice

Abstract: *The paper presents the current state of air pollution assessment. Air pollution is currently realized by air pollution indices and air stress indices. However, these approaches have some limitations which can be eliminated e.g. using systems based on fuzzy logic. Therefore, we design a hierarchical fuzzy inference system for air pollution assessment using data from Pardubice micro region.*

Keywords: *Air Pollution, Air Quality, Fuzzy Logic, Hierarchical Fuzzy Inference System.*

1. Introduction

Air stress indices and air quality indices were developed to assess the integral ambient air pollution. They are determined as (weighted) mean values of selected air pollutants. Strictly given limits are set for air pollutants. Local conditions and synergic relations between air pollutants and other meteorological factors are not taken into account. The stated limitations can be eliminated e.g. using systems based on fuzzy logic. Fuzzy sets allow expressing object attributes which can have non-numeric values as numeric. Numeric nature of values can deeply influence model design. Currently, application of fuzzy sets is moving from technical sciences to economic, environmental and social sphere [20, 21]. That allows processing semantics of natural language in these science branches. The main characteristics of natural language semantics is its uncertainty. Uncertainty in fuzzy sets theory can be quantified [11,27]. Communication in management and decision-making is often realized based on natural language that is why it is vague and uncertain. This fact leads to solving the uncertainty by transforming speech meaning, given by natural language semantics, to a set of real numbers by fuzzy sets. Simultaneously, it allows learning the computer to understand natural language.

Assessment of the i-th district $o_i^t \in O$, $O=\{o_1^t, o_2^t, \ldots, o_i^t, \ldots, o_n^t\}$ in time t to the j-th class $\omega_{i,j}^t \in \Omega$, $\Omega=\{\omega_{1,j}^t, \omega_{2,j}^t, \ldots, \omega_{i,j}^t, \ldots, \omega_{n,j}^t\}$ can be realized by fuzzy inference systems (FISs). Based on FIS it is possible to define hierarchical fuzzy inference systems (HFISs) as the assessment process becomes more efficient and it is better interpretable. The paper is structured as follows. First, current approaches to air quality indices are introduced. Then the parameters are designed which are consequently applied for the modelling by a HFIS. Finally the analysis of results is provided.

2. Air Pollution Assessment

Both the air stress indices (ASIs) and air quality indices (AQIs) consider relevant air pollutants (e.g. CO, NO_2, O_3, PM_{10} and SO_2) frequently monitored at long-term stations within air pollution monitoring networks. Air stress indices aggregate relative concentrations of different air pollutants, i.e. per air pollutant the ratio of ambient concentration and reference value [16]. As a result, air stress indices do not show a pronounced relation to people. In contrast, air quality indices quantify the impacts of a mixture of air pollutants, which is typical of the ambient air, on well-being and health of people in a graded way, i.e. they are impact related with respect to people. Current AQIs show some differences, which are summarised by

[25], e.g. different number of index classes or different class boundaries. A well-known index is the AQI developed by Environmental Protection Agency (EPA) [5]. It is defined with respect to the five main common pollutants, i.e. CO, NO_2, O_3, PM_{10} and SO_2. Modified versions of the AQI of EPA were developed by [17] taking into consideration the limit values ruling in Europe. An aggregate AQI based on the combined effects of five criteria pollutants (CO, SO_2, NO_2, O_3 and PM_{10}) taking into account the European standards was developed by [15]. The AQI uses both the direct numerical expression and the linguistic description. The values of air pollutants are transformed into a dimensionless number characterizing the state of air pollution. Based on the value of the AQI the state of air pollution can be classified into six classes. A sample of classes $\omega_{i,j}^{t} \in \Omega$ for the AQI of the Czech National Institute of Public Health (CNIPH) is presented in Table 1.

Table 1 AQI classes $\omega_{i,j}^{t} \in \Omega$ of the CNIPH

AQI	$\omega_{i,j}^{t}$	Class description
$\langle 0,1)$	$\omega_{i,1}^{t}$	Clean air, very healthy environment.
$\langle 1,2)$	$\omega_{i,2}^{t}$	Satisfactory air, healthy environment.
$\langle 2,3)$	$\omega_{i,3}^{t}$	Slightly polluted air, acceptable environment.
$\langle 3,4)$	$\omega_{i,4}^{t}$	Polluted air, environment dangerous for sensitive population.
$\langle 4,5)$	$\omega_{i,5}^{t}$	High polluted air, environment dangerous for the whole population.
$\langle 5,6)$	$\omega_{i,6}^{t}$	Very high polluted air, harmful environment.

Another AQI used in the Czech Republic was developed by the Czech Hydro meteorological Institute. The AQI is based on the results of weight concentrations measures of substances in the air (Table 2). The evaluation takes the possible influence of human health into account [23].

Table 2 AQI of the Czech Hydro meteorological Institute

Air quality	SO_2	NO_2	CO	O_3	PM_{10}
	1h [$\mu g.m^{-3}$]		8h [$\mu g.m^{-3}$]	1h [$\mu g.m^{-3}$]	
Very good	0-25	0-25	$0\text{-}1.10^3$	0-33	0-15
Good	25-50	25-50	$1.10^3\text{-}2.10^3$	33-65	15-30
Favourable	50-120	50-100	$2.10^3\text{-}4.10^3$	65-120	30-50
Satisfactory	120-250	100-200	$4.10^3\text{-}1.10^4$	120-180	50-70
Bad	250-500	200-400	$1.10^4\text{-}3.10^4$	180-240	70-150
Very bad	>500	>400	$>3.10^4$	>240	>150

The Pollution Standards Index (PSI) was initially established in response to a dramatic increase in the number of people suffering respiratory irritation due to the deteriorating air quality. The PSI was revised, renamed to the AQI, and subsequently implemented in 1999 by the United States EPA. The new system includes breakpoints for ozone (O_3), a sub-index of 8-hour average O_3 concentrations, and a new sub-index for fine particulate matter ($PM_{2.5}$). However, even though AQI has completely replaced PSI in the United States, a greater part of the world still could not adopt the AQI system, mainly because the lack of $PM_{2.5}$ measurement capability. The Revised AQI (RAQI) is derived from the AQI, and is a background arithmetic mean index and a background arithmetic mean entropy index [10]. However, PM_{10} total mass measurement may be not sufficient as air quality index due to its complex composition since the metal content of PM10 is not related to its total mass, especially in sites with industrial activities [4]. A uniform indexing scale using well pre-established air quality standards and at the same time accounting for local conditions assessed via statistical analysis of data recorded at each monitoring station was proposed by [12] and implemented at the Athens metropolitan area. Air quality indices with unlike goals are also reported in the literature. A daily quality index was proposed by [1] to show exceeding limit values. The example of the development of an alternative AQI is used by [24] to illustrate issues related to quantifying the public health burden attributable to air pollution. The common air quality index (CAQI) proposed by [25] is a set of two indices: one for roadside monitoring sites and one for average city background conditions. A class of AQIs was developed by [2] which are easy to understand by citizens and policy-makers. They are constructed in order to be able to compare situations that differ in time and space. The hierarchical aggregation here proposed is based on the successive selection of order statistics, i.e. on percentiles and on maxima. A Pollution Index (PI) with the same objective has been applied assuming limit values established by EC [8]. Air pollution indexes have also been proposed for air pollution forecasts as reported by [3]. In this paper a PI has been proposed and implemented at the urban area of Naples. A modified version of the index has been developed assuming additive effects of pollutants. The procedure to evaluate the PI on the overall urban area is also reported. However, due to inconsistency and distinction of each air pollutant, there is a vagueness or fuzziness in air quality. Fuzziness makes the use of sharp boundaries in classification schemes hard to justify. A small increase/decrease in pollutant data, near its boundary value, will change its class. Moreover, different breakpoint concentration values and air quality standards are reported in the literature [6, 26]. Further, it would be significant to consider local conditions when defining breakpoint concentrations. As a matter of fact, different areas of the world are characterised by different climatic conditions influencing the effect of atmospheric pollutants on human health and also the response of population to air pollution could be different. This fuzziness led some environmental researchers to look for advanced assessment methods based on fuzzy logic [7], such as fuzzy synthetic evaluation [21]. Another issue is coupled to the fact that there are several pollutants presented simultaneously in the atmosphere. Therefore, the effects on human health due to the simultaneous presence of different pollutants in the atmosphere should be considered. Knowledge of the effects of a mixture of air pollutants on human health is at present limited. An attempt in considering this effect in the evaluation of PIs was proposed by [13] using a constant elasticity of substitution function but the absence of epidemiological data did not allow the assumption of the proper values for the parameters contained in the function.

3. Problem Formulation

Harmful substances in the air represent the parameters of air quality modelling. They are defined as the substances emitted into the external air or generated secondarily in the air which harmfully influent the environment directly, after a physical or chemical transformation or eventually in the interaction with other substances. Except the harmful substances, other components influence the overall air pollution. For example, ozone, solar radiation, the speed or the direction of wind, air humidity and air pressure represent these components. Both the parameters concerning the harmful substances in the air and the meteorological parameters influence air quality development. The interaction of both types of parameters can cause an increase of air pollution and influence the human health this way. The design of the parameters, based on previous correlation analysis and recommendations of notable experts, can be realized as presented in Table 3.

Table 3 Parameters design for air quality modelling

Parameters	
Harmful substances	$x_1^t = SO_2$, SO_2 is sulphur dioxide.
	$x_2^t = O_3$, O_3 is ozone.
	x_3^t = NO, NO_2 (NO_x) are nitrogen oxides.
	x_4^t = CO, CO is carbon monoxide.
	$x_5^t = PM_{10}$, PM_{10} is particulate matter (dust).
Meteorological	x_6^t = SW, SW is the speed of wind.
	x_7^t = DW, DW is the direction of wind.
	$x_8^t = T_3$, T_3 is the temperature 3 meters above the Earth's surface.
	x_9^t = RH, RH is relative air humidity.
	x_{10}^t = AP, AP is air pressure.
	x_{11}^t = SR is solar radiation.

Based on the presented facts, the following data matrix **P** can be designed

$$\mathbf{P}=\begin{array}{c|ccccc:c} & x_1^t & \dots & x_k^t & \dots & x_m^t & \\ \hline o_1^t & x_{1,1}^t & \dots & x_{1,k}^t & \dots & x_{1,m}^t & \omega_{1,j}^t \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ o_i^t & x_{i,1}^t & \dots & x_{i,k}^t & \dots & x_{i,m}^t & \omega_{i,j}^t \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ o_n^t & x_{n,1}^t & \dots & x_{n,k}^t & \dots & x_{n,m}^t & \omega_{n,j}^t \end{array},$$

where $o_i^t \in O$, $O=\{o_1^t, o_2^t, \dots, o_i^t, \dots, o_n^t\}$ are objects (districts) in time t, x_k^t is the k-th parameter in time t, $x_{i,k}^t$ is the value of the parameter x_k^t for the i-th object $o_i^t \in O$, $\omega_{i,j}^t \in \Omega$ is the j-th class assigned to the i-th object $o_i^t \in O$, $\mathbf{p}_i^t = (x_{i,1}^t, x_{i,2}^t, \dots, x_{i,k}^t, \dots, x_{i,m}^t)$ is the i-th pattern, $\mathbf{x}^t = (x_1^t, x_2^t, \dots, x_k^t, \dots, x_m^t)$ is the parameters vector. The monthly values of parameters $\mathbf{x}^t = (x_1^t, x_2^t, \dots, x_k^t, \dots, x_m^t)$, m=11 for $o_i^t \in O$, $O=\{o_1^t, o_2^t, \dots, o_i^t, \dots, o_n^t\}$, districts in the city of Pardubice, Czech Republic, (Fig. 1) represent the data set **P**.

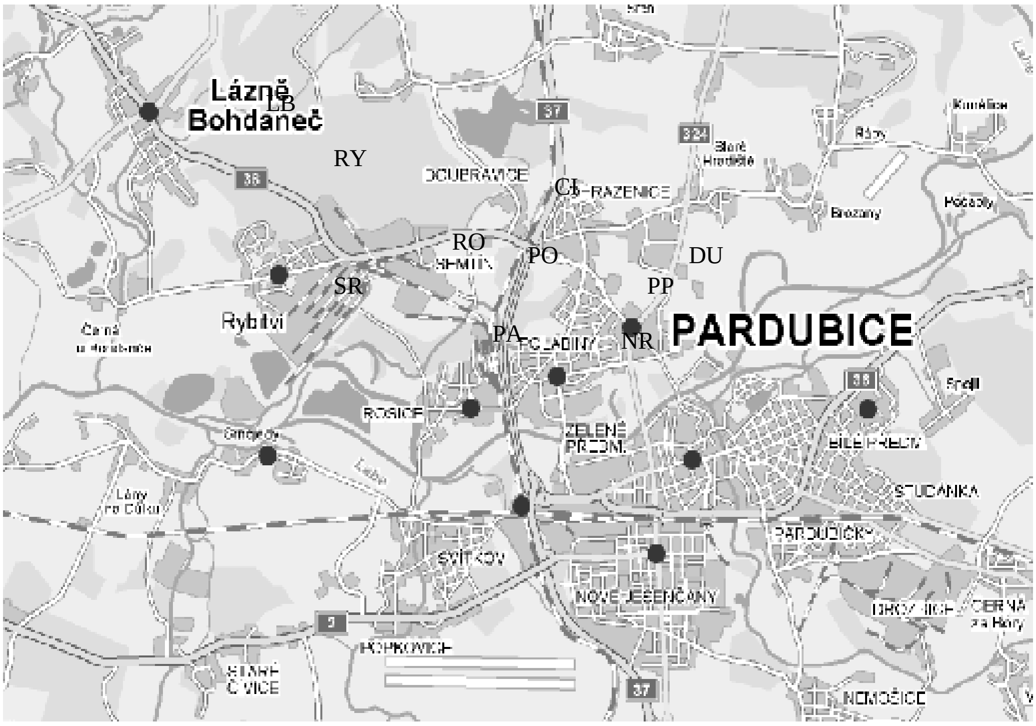

Fig. 1 The map of the districts (black points)

Legend: Bus stops: (Cihelna (CI), Dubina (DU), Polabiny (PO), Rosice (RO), Rybitví (RY), Srnojedy (SR)), crossroads: (Palacha-Pichlova (PP), Náměstí Republiky (NR)), Lázně Bohdaneč (LB), chemical factory of Paramo (PA).

4. Hierarchical Fuzzy Inference Systems Design

General structure of FIS [9,14,18,19,22] contains a fuzzification process of input variables by membership functions, design base of IF – THEN rules (BRs) or automatic IF – THEN rules extraction from input data, operators (AND, OR, NOT) application in rules, implication and aggregation within these rules and process of defuzzification of gained values to crisp values. In the process of defuzzification, standardization of inputs and their transformation to domain of values of membership function takes place. Inference mechanism in based on operations of fuzzy logic and implication within IF – THEN rules [14,19,22]. Based on aggregation process, transformation of outputs of individual IF – THEN rules to the output fuzzy set occurs. In process of defuzzification conversion of fuzzy values to expected crisp values is realized.

Let there exist the FIS of Mamdani type defined in [22]. Then the number of IF – THEN rules $p_{FIS}=k^m$, where k is the number of membership functions, m is the number of input variables. For a great number m of input variables, the FIS of Mamdani type may be inefficient due to the increase in the number p_{FIS} of IF – THEN rules. One of the ways to reduce the number p_{FIS} of IF – THEN rules is to design the FIS of Mamdani type with a hierarchical structure. The aim of HFIS design is to reach efficiency and ability to interpret (i.e. with small number p_{FIS} of IF – THEN rules with small number of variables m, and with a small number k of membership functions for each variable). Reducing the number p_{FIS} of IF – THEN rules leads to a reduction in computing demand of the system. This way, it comes to be more effective. The minimum number p_{HFIS} of IF-THEN rules is achieved if each subsystem in the HFIS has only 2 inputs (v=2). Basic types of HFISs are a tree and cascade HFIS [19,20]. Based on HFIS types mentioned, it is possible to design various different (hybrid) HFISs.

Let $x_1^t, x_2^t, \ldots, x_i^t, \ldots, x_m^t$ be input variables, and let $y_\mu^{1,1}, y_\mu^{1,2}, \ldots, y_\mu^{q,1}$ be the outputs of subsystems $FIS_\mu^{1,1}, FIS_\mu^{1,2}, \ldots, FIS_\mu^{q,1}$, where μ are membership functions. Then IF – THEN rules $R^{h_{1,1}}, R^{h_{1,2}}, \ldots, R^{h_{q,1}}$ of the tree HFIS, presented in Fig. 2, where q is the number of layers, can be defined as follows:

Layer 1: $FIS_\mu^{1,1}$ $R^{h_{1,1}}$: IF x_1^t is $A_1^{h_{1,1}}$ AND x_2^t is $A_2^{h_{1,1}}$ THEN $y_\mu^{1,1}$ is $B^{h_{1,1}}$,
$FIS_\mu^{1,2}$ $R^{h_{1,2}}$: IF x_3^t is $A_3^{h_{1,2}}$ AND x_4^t is $A_4^{h_{1,2}}$ THEN $y_\mu^{1,2}$ is $B^{h_{1,2}}$,
... (1)
Layer q: $FIS_\mu^{q,1}$ $R^{h_{q,1}}$: IF $y_\mu^{q-1,1}$ is $B^{h_{q-1,1}}$ AND $y_\mu^{q-1,2}$ is $B^{h_{q-1,2}}$ THEN $y_\mu^{q,1}$ is $B^{h_{q,1}}$,

where: $h_{1,1}=h_{1,2}=\ldots=h_{q,u}=\{1,2, \ldots ,k^m\}$, u=1,2, $A_1^{h_{1,1}}, A_2^{h_{1,1}}, \ldots, A_n^{h_{q,1}}$ are linguistic variables corresponding to fuzzy sets represented as $\mu_1^{h_{1,1}}(x_i^t), \mu_2^{h_{1,1}}(x_i^t), \ldots, \mu_m^{h_{q,1}}(x_i^t)$, $B^{h_{1,1}}, B^{h_{1,2}}, \ldots, B^{h_{q,1}}$ are linguistic variables corresponding to fuzzy sets represented as $\mu^{h_{1,1}}(y_\eta^{1,1}), \mu^{h_{1,2}}(y_\eta^{1,2}), \ldots, \mu^{h_{q,1}}(y_\eta^{q,1}), \mu_{B^{h_{1,1}}}(y_j^{1,1}), \mu_{B^{h_{1,2}}}(y_j^{1,2}), \ldots, \mu_{B^{h_{q,1}}}(y_j^{q,1})$ are membership function μ values of aggregate fuzzy set for outputs $y_j^{1,1}, y_j^{1,2}, \ldots, y_j^{q,1}$.

The outputs $y_j^{1,1}, y_j^{1,2}, \ldots, y_j^{q,1}$ of particular subsystems $FIS_\mu^{1,1}, FIS_\mu^{1,2}, \ldots, FIS_\mu^{q,1}$ of the tree HFIS can be expressed by using defuzzification method Center of Gravity (COG) [19].

Input data of the tree HFIS contains parameters $\mathbf{x}^t=(x_1^t, x_2^t, \ldots, x_k^t, \ldots, x_m^t)$, m=11. The output contains classifications of objects into classes $\omega_{i,j}^t \in \Omega$. The design of this model reduces number of p_{FIS} IF – THEN rules. An important part of the model is, besides reducing number of p_{FIS} IF – THEN rules, to reproduce expert decisions in air quality modelling process, in the sense of impeaching relationships of parameters $\mathbf{x}^t=(x_1^t, x_2^t, \ldots, x_k^t, \ldots, x_m^t)$, m=11 and their mutual relations.

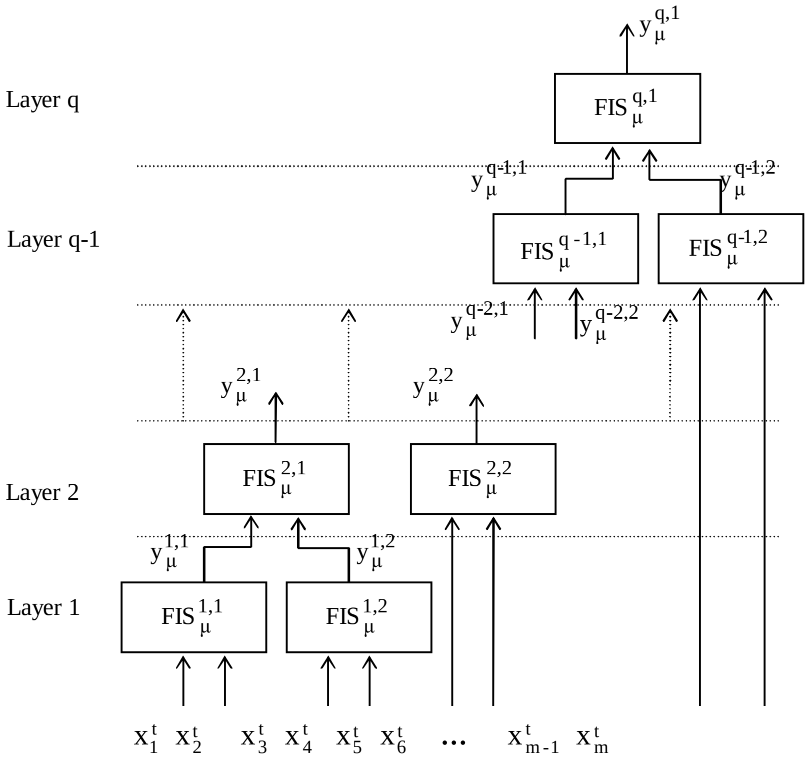

Fig. 2 A tree HFIS

5. Analysis of the Results

The design of the tree HFIS is based on the assessment of synergic relations among the harmful substances each other, and between harmful substances and meteorological factors. This is concerned with the following facts especially. When evaluating PM_{10} and SO_2 at the same time, the synergic component has to be involved. Further, the estimation of secondary oxidants in the air is determined based on the concentration of the sum of NO_x and solar radiation. The design of input and output membership functions is realized by fuzzy cluster analysis taking into account local conditions. Input parameters x_k^t are represented by three bell membership functions. Individual membership functions are described by linguistic variables values small_value_ x_k^t, medium_value_ x_k^t and great_value _ x_k^t. The base of IF – THEN rules is proposed by local experts in air quality evaluation. It has following form:

$FIS_\mu^{1,1}$ R^1: IF x_1^t is small_value_ x_1^t AND x_2^t is small_value_ x_2^t THEN $y_\mu^{1,1}$ is small_value_ $y_\mu^{1,1}$,
$FIS_\mu^{1,1}$ R^2: IF x_1^t is medium_value_ x_1^t AND x_2^t is medium_value_ x_2^t THEN $y_\mu^{1,1}$ is small_value_ $y_\mu^{1,1}$,
. . . (2)
$FIS_\mu^{1,1}$ R^9: IF x_1^t is great_value_ x_1^t AND x_2^t is great_value_ x_2^t THEN $y_\mu^{1,1}$ is great_value_ $y_\mu^{1,1}$,
. . .
$FIS_\mu^{5,1}$ R^1: IF $y_\mu^{4,1}$ is small_value_ $y_\mu^{4,1}$ AND $y_\mu^{4,2}$ is small_value_ $y_\mu^{4,2}$ THEN $y_\mu^{5,1}$ is $\omega_{i,5}^t$,
$FIS_\mu^{5,1}$ R^2: IF $y_\mu^{4,1}$ is small_value_ $y_\mu^{4,1}$ AND $y_\mu^{4,2}$ is medium_value_ $y_\mu^{4,2}$ THEN $y_\mu^{5,1}$ is $\omega_{i,5}^t$,
. . . (3)
$FIS_\mu^{5,1}$ R^9: IF $y_\mu^{4,1}$ is great_value_ $y_\mu^{4,1}$ AND $y_\mu^{4,2}$ is great_value_ $y_\mu^{4,2}$ THEN $y_\mu^{5,1}$ is $\omega_{i,1}^t$.

Classifications of the i-th district $o_i^t \in O$ in time t to the j-th class $\omega_{i,j}^t \in \Omega$ are displayed in Table 4. The results show that the classes $\omega_{i,j}^t \in \Omega$ obtained by the HFIS make it possible to realize the uncertainty in such a way that the value of membership function $\mu(\omega_{i,j}^t)$ is known for each class $\omega_{i,j}^t \in \Omega$. Three classes $\omega_{i,2}^t, \omega_{i,3}^t$ and $\omega_{i,4}^t$ dominate in the year measurements. Polluted air ($\omega_{i,4}^t$) has been detected in the centre of the town (PP, NR) due to traffic. It is obvious that there is a slight improvement of the air quality in the monitored districts $o_i^t \in O$ during the time t = 2001, 2002, … ,2006.

Table 4 Air quality classes $\omega_{i,j}^t \in \Omega$ for districts in years 2001-2006

Classes of the AQI based on the HFIS with membership function values										
year	SR	RY	RO	PP	PO	PA	NR	LB	DU	CI
2001	$\omega_{i,3}^t$ 0.55	$\omega_{i,3}^t$ 0.90	$\omega_{i,2}^t$ 0.80	$\omega_{i,4}^t$ 0.93	$\omega_{i,3}^t$ 0.94	$\omega_{i,3}^t$ 0.91	$\omega_{i,4}^t$ 0.95	$\omega_{i,3}^t$ 0.76	$\omega_{i,3}^t$ 0.90	$\omega_{i,3}^t$ 0.94
2002	$\omega_{i,3}^t$ 0.90	$\omega_{i,3}^t$ 0.90	$\omega_{i,2}^t$ 0.70	$\omega_{i,4}^t$ 0.95	$\omega_{i,3}^t$ 0.95	$\omega_{i,4}^t$ 0.95	$\omega_{i,4}^t$ 0.95	$\omega_{i,3}^t$ 0.80	$\omega_{i,3}^t$ 0.95	$\omega_{i,3}^t$ 0.90
2003	$\omega_{i,2}^t$ 0.63	$\omega_{i,3}^t$ 0.90	$\omega_{i,2}^t$ 0.95	$\omega_{i,4}^t$ 0.90	$\omega_{i,3}^t$ 0.90	$\omega_{i,3}^t$ 0.94	$\omega_{i,4}^t$ 0.95	$\omega_{i,3}^t$ 0.59	$\omega_{i,3}^t$ 0.90	$\omega_{i,3}^t$ 0.95
2004	$\omega_{i,2}^t$ 0.63	$\omega_{i,3}^t$ 0.93	$\omega_{i,2}^t$ 0.82	$\omega_{i,4}^t$ 0.95	$\omega_{i,3}^t$ 0.90	$\omega_{i,4}^t$ 0.79	$\omega_{i,4}^t$ 0.94	$\omega_{i,3}^t$ 0.84	$\omega_{i,3}^t$ 0.91	$\omega_{i,3}^t$ 0.90
2005	$\omega_{i,2}^t$ 0.90	$\omega_{i,3}^t$ 0.90	$\omega_{i,2}^t$ 0.66	$\omega_{i,4}^t$ 0.95	$\omega_{i,3}^t$ 0.94	$\omega_{i,3}^t$ 0.94	$\omega_{i,4}^t$ 0.92	$\omega_{i,3}^t$ 0.94	$\omega_{i,3}^t$ 0.90	$\omega_{i,3}^t$ 0.91
2006	$\omega_{i,2}^t$ 0.90	$\omega_{i,3}^t$ 0.95	$\omega_{i,2}^t$ 0.80	$\omega_{i,4}^t$ 0.95	$\omega_{i,2}^t$ 0.74	$\omega_{i,3}^t$ 0.57	$\omega_{i,4}^t$ 0.91	$\omega_{i,3}^t$ 0.76	$\omega_{i,3}^t$ 0.92	$\omega_{i,3}^t$ 0.93

In addition to yearly values, the monthly values of the air quality classes $\omega_{i,j}^t \in \Omega$ have been also evaluated by the HFIS. Based on the experiments with the data, five classes were observed in the data structure. The classes correspond to those presented in Table 1 with the difference that the class $\omega_{i,6}^{t}$ is not used. Concerning monthly measurements, the classification of the i-th district $o_i^t \in O$ in time t (months) to the j-th class $\omega_{i,j}^{t} \in \Omega$ by the HFIS and their frequencies f are shown in Fig 3. The model of the HFIS classifies districts $o_i^t \in O$ so that classes $\omega_{i,2}^{t}, \omega_{i,3}^{t}, \omega_{i,4}^{t}$ have highest percentages. That means that areas with slightly polluted air prevail.

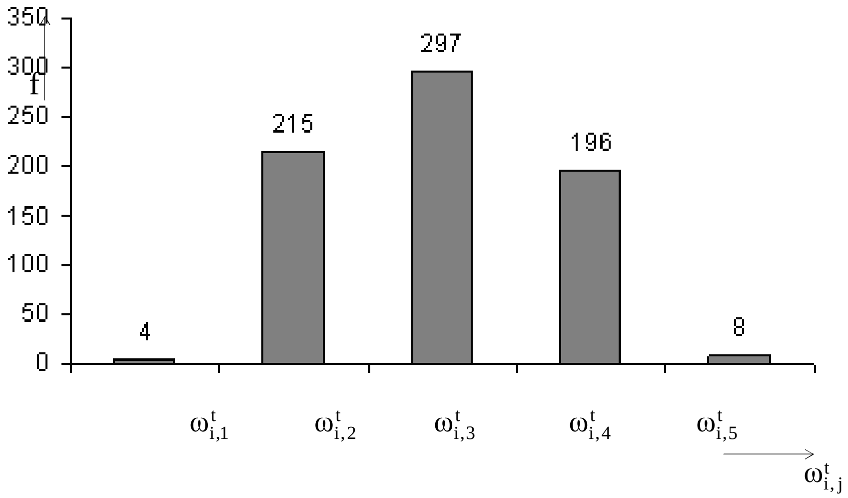

Fig. 3 Classification of the districts $o_i^t \in O$ into classes $\omega_{i,j}^{t} \in \Omega$, j=5 by the tree HFIS (the frequencies f of the classes)

6. Conclusion

The paper contains possibilities of HFIS design for air quality assessment. The air quality assessment task is disassembled to elementary tasks, which are trivially solvable. Trivially solvable tasks are represented by individual partial subsystems $FIS_{\mu}^{1,1}, FIS_{\mu}^{1,2}, \dots, FIS_{\mu}^{q,1}$, q=5 for the tree HFIS. Hierarchical fuzzy inference system designed in this manner is applied in model for air quality classification in the city of Pardubice, the Czech Republic. It is classification of the i-th district $o_i^t \in O$ in time t to the j-th class $\omega_{i,j}^{t} \in \Omega$ in time t. Designed model with the tree HFIS is, considering its efficiency and interpretability, a suitable tool for air quality assessment. This model allows processing semantic uncertainty. It represents efficient solution based on computational intelligence methods. It takes into account expert's decision-making in air quality modelling, thus takes into account relationships among parameters $\mathbf{x}^t=(x_1^t, x_2^t, \dots, x_k^t, \dots, x_m^t)$, m=11 and their mutual relations. The results can represent recommendations to Pardubice state administration in the area of air quality progress. The model design was carried out in Matlab Simulink in the MS Windows XP operation system.

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Contacts address:

Ing. Petr Hájek, Ph.D.
Institute of System Engineering and Informatics
Faculty of Economics and Administration
University of Pardubice
Studentská 84, 532 10 Pardubice
Email: petr.hajek@upce.cz

prof. Ing. Vladimír Olej, CSc.
Institute of System Engineering and Informatics
Faculty of Economics and Administration
University of Pardubice
Studentská 84, 532 10 Pardubice
Email: vladimir.olej@upce.cz