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Addressee-Tailored Interpretation of Air Quality Data

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Abstract

Most of the available air quality information systems deliver only raw air quality data like pollutant concentrations. This raw data is rarely self-explanatory and is not sufficient to inform the general public on air quality. To provide comprehensive air quality information to the public the data has to be assessed and interpreted focusing on the addressees requirements. These requirements differ a lot depending on social, cultural and knowledge backgrounds or the state of health. This paper will show how this user tailored interpretation is implemented in the EU funded project MARQUIS (Multimodal AiR QUality Information Service for General Public).

1. Introduction

Citizens are more and more aware of the relevance of environmental information, especially air quality for their everyday life – be it for professional or private reasons. This growing interest is not limited to specific social groups or a specific region in Europe. Rather, the nature of the requested information varies a lot among the different interested parties depending on social, cultural and knowledge backgrounds or their state of health.

The public request for information is supported by the European Directive 1996/62/EC on ambient air quality assessment and management and its daughter directives and by the European Directive 2003/4/EC on public access to environmental information (EC 1996, 2003). These directives commit authorities to offer exhaustive information on air quality to citizens in a comprehensive form. Unfortunately the reality looks different: Current environmental services typically present "raw" data on air quality conditions. This kind of (raw) environmental data is rarely self-explanatory and cannot be understood by laymen. Thus these services fail to inform at least the general public.

In order to be informative, interpretation and tailoring is required to match e.g. health, interest and knowledge profiles of citizens. This approach was realized in the EU funded project MARQUIS (Multimodal AiR QUality Information Service for General Public) (Wanner et al. 2007a, 2007b). Its goal is to generate multilingual, multimodal, cross-border information out of raw data and make it available in the indicated way via several communication platforms. In short, the characteristic features of the MARQUIS-Service are:

(i) coverage of the major air pollutant substances monitored in five European regions;[4]
(ii) reference to a default user profile typology, with the option of a flexible individualization of each profile by the users;
(iii) coverage of the major modern communication channels: web, email, mobile phone services (SMS, WAP, and MMS), TV, and printed media;

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[4] The following regions are covered in MARQUIS: Baden-Württemberg (Germany), Catalonia (Spain), Finland, Portugal and Upper Silesia (Poland).

(iv) use of advanced air quality assessment and interpretation models;
(v) use of natural language processing techniques for planning and generation of multimodal and multilingual material.[5]

In this paper the approach of tailoring air quality information to user needs in MARQUIS is described. For a more detailed presentation of the whole MARQUIS system, see (Wanner et al., 2007a) as well as the publicly available deliverables of the MARQUIS-project.

2. Overview about the MARQUIS system

Technically, MARQUIS is a distributed service in that the raw AQ data verification and selected forecasting modules are run remotely on the servers of the data providers, while the common database, the assessment and interpretation and information production modules are run on the central MARQUIS-service. Given that nearly all involved tasks are time consuming, the realization of the most efficient architecture possible was an issue. A two-pipe architecture with the following distribution of the tasks among the pipes proved to be most adequate:

Pipe 1:

(i) Monitoring of air pollutant concentrations and of meteorological conditions in the five MARQUIS regions and execution of data quality assurance and air pollution forecasting models.[6]
(ii) Delivery of the measured and forecasted data from the local DBs to the MARQUIS-server, where they are kept in the central DB in a uniform format.
(iii) Assessment and interpretation of the delivered data with respect to their relevance to any of the EU and regional environmental legislation issues and to any of the MARQUIS users with a profile from the user profile typology; determining the primary meteorological and contextual influence on the measured and forecasted air quality (for explaining / justifying them).

Pipe 2:

(i) Receiving an information request from a user via the MARQUIS-Client interface (this can be a singular or an automated periodic request).
(i) Selecting the content that is relevant to the user in question from the structure produced in Step 3 of Pipe 1.
(ii) Generating the discourse structure of the content to be conveyed to the user, determining the appropriate mode for the individual chunks of the content, and starting the corresponding information generators.
(iii) Generating the information with the table, graphic and multilingual text generators.
(iv) Conveying the generated information to the user using his/her preferred communication channel.

[5] The information is offered in terms of texts, tables and graphics (including pictograms). Textual information is provided in eight languages: in the primary languages of the regions (German, Catalan and Spanish, Finnish, Portuguese, Polish) as well as in English (the "lingua franca of the EU") and French (the language of the neighbour region of Baden-Württemberg and Catalonia).
[6] The meteorological data are provided by the Finnish Meteorological Institute for Finland, Baden-Württemberg and Upper Silesia; by the Portuguese Meteorology Institute for Portugal, and by the Catalan Meteorological Service for Catalonia.

To account for these tasks, the architecture contains the following modules: central MARQUIS DB, AQ assessment and interpretation module, document planning module, and information generation module. Each of the modules consists of several submodules (Wanner et al., 2007a).

3. The user typology in MARQUIS

Air quality information must be tailored to specific user groups (Johansen et al., 2001). Often, as system developers, we are tempted to think that we know what the different user groups are and what kind of information each of the groups needs. However, interviews with users may turn out to be a surprise. Empirical studies of the user market and interviews with a representative number of users with different backgrounds are absolutely indispensable.

In MARQUIS, a qualitative study has been carried out first in Catalonia and then adapted to the other test regions. The study consisted in structured and semi-structured personal interviews with representatives of target groups considered as potential users of the service. About 100 individuals have been interviewed in each region. All results were analyzed to define the user profiles and the preferences of the users with respect to the type of content and presentation mode. The user study resulted in a definition of an initial user profile typology which predefines the content to be provided to a user who accesses the service for the first time and identifies him-/herself as member of one of the user groups of the typology. Figure 1 displays the user profile typology.

The initial user profiles can be customized with respect to content, language, mode of presentation, etc. via a web-based interface. The option of customization is important, e.g., in the case of cross-border users, of people who travel from one region to another, or users who are end users and information brokers at the same time. The user typology itself can also be extended in order to account for new user groups.

1. Consultant/AQ-Technician

2. Medical professional
2.1 Asthma specialist
2.2 Specialist for other respiratory diseases
2.3 Specialist for non-respiratory diseases

Patient
3.1 Asthma patient
3.2 Patient- Other respiratory diseases

General Public
4.1 Printed Media Reader
4.2 Television Viewer
4.3 Mobile Phone User
4.4 Internet User

Information Broker
5.1 Printed Media
5.2 Television
5.3 Mobile Phone Services
5.4 Internet Portals

Figure 3.1: User profile typology in MARQUIS

4. AQ assessment and interpretation

The assessment and interpretation module is the main interface between the raw data from the MARQUIS database and the document planning and generation modules. Its role is to assess and interpret the raw data regarding the relevance for different users and extract the maximum information out of it. Thus it can be considered an "expert system shell" since it contains the know-how of the air quality specialist in a distilled form.

This module is located in the first pipe of the MARQUIS system and is therefore independent of any specific user request (i.e., it is not focussing on a single user profile). In fact it has to take care of all possible user requirements and provide the extracted information via XML. The actual content selection for a specific user request is done by the document planning in the next step (Bouayad-Agha and Wanner, 2007). The main interpretation and assessment tasks are described in the following.

4.1 Air quality indices (AQIs)

The basis of air quality information are always measured or modelled air pollutant concentrations. But this raw data is rarely understandable by non-specialists. Thus concentrations have to be assessed to put them into a manner which can be easily understood by the general public. A good instrument for this kind of assessment is an air quality index (AQI). An AQI translates air pollutant concentrations to ratings like "good" or "poor" air quality (see Figures 4.1 - 4.3).

Most air quality indices are using pollutant specific rating scales and map each pollutant concentration onto an index class. The worst classified pollutant is reliable for the AQI. This integrates the contribution of the measured concentration of each pollutant to the overall air quality in a single figure.

Unfortunately there is no common European AQI – in some countries there is not even a national one but different ones in different regions. Regarding some AQIs used in the MARQUIS test region it is remarkable that they differ a lot in the scale, pollutant concentrations and even in the color schemes used to display them. Some examples in detail:

- In Finland the lowest index number is the best, in Catalonia the highest one express "excellent air quality".
- Comparing the rating for CO concentrations – a concentration of 5 mg/m^3 means in Catalonia "excellent air quality", in Finland "satisfactory" but in Baden-Württemberg only "adequate".
- In Finland the rating for PM_{10} is based on hourly values, in Baden-Württemberg and Catalonia it is based on 24h means.

The reasons for the different AQIs are multi-faceted and this issue would go beyond the scope of this paper. But it is assumed that it is not easily possible to converge to one European index even if there are some approaches, e.g. in the CITEAIR Project (van den Elshout et al., 2007). Thus the approach of MARQUIS is to use the AQI of the users' home region to inform them on the air quality, no matter if they ask for information in their town or elsewhere in Europe. This enables citizens to understand and compare the situation in different European regions. Furthermore some of the AQIs take into account regional customs like e.g. the Baden-Württemberg one which is based on German scholar grades and thereby intuitively understandable in this region. This user-friendliness would be lost using a common index for Europe.

in-dex	rating	PM10 (µg/m³) 24h	O3 (µg/m³) 1h	NO2 (µg/m³) 1h	SO2 (µg/m³) 1h	CO (mg/m³) 8h
1	very good	0,0 - 9,9	0 - 32	0 - 24	0 - 24	0,0 – 0,9
2	good	10,0 - 19,9	33 - 64	25 - 49	25 - 49	1,0 – 1,9
3	satisfactory	20,0 - 34,9	65 - 119	50 - 99	50 - 119	2,0 – 3,9
4	adequate	35,0 - 50	120 - 180	100 - 200	120 - 350	4,0 – 9,9
5	poor	51,0 - 99,9	181 - 240	201 - 499	351 - 999	10,0 - 29,9
6	very poor	> 100,0	> 241	> 500	> 1000	> 30,0

Figure 4.1: TLQ – the air quality index of Baden-Württemberg, Germany

index	PM10 (µg/m³) 24h	O3 (µg/m³) 1h	NO2 (µg/m³) 1h	SO2 (µg/m³) 1h	CO (mg/m³) 8h
100	0	0	0	0	0
50	35	90	115	200	6
0	50	180	240	350	10
-100	350	400	1130	1500	17
-200	420	800	2260	3000	34
-300	500	990	3000	3750	46
-400	600	1200	3750	4900	58

Good	**Excellent** air quality	75 ≤ ICQA ≤ 100
50 ≤ ICQA ≤ 100	**Satisfactory** air quality	50 ≤ ICQA < 75
Improvable	**Acceptable** air quality	25 ≤ ICQA < 50
0 ≤ ICQA < 50	**Low** air quality	0 ≤ ICQA < 25
Poor	**Deficient** air quality	-50 ≤ ICQA < 0
ICQA < 0	**Extremely deficient** air quality	ICQA < -50

Figure 4.2: ICQA – the air quality index of Catalonia, Spain

index	PM10 (µg/m³) 1h	O3 (µg/m³) 1h	NO2 (µg/m³) 1h	SO2 (µg/m³) 1h	CO (mg/m³) 8h
50	20	60	40	20	4
75	70	120	70	80	8
100	140	150	150	250	20
150	210	180	200	350	30

index	rating
0 - 50	good
51 - 75	satisfactory
76 - 100	fair
101 - 150	poor
> 151	very poor

Figure 4.3: The YTV air quality index used in the Helsinki metropolitan area Finland

4.2 Assessment of health impacts

Beside the AQI which gives the user information what the air quality is like it's of big importance to make a statement what impacts the air quality has on human health. Normally non-specialists can not assess if and what impacts air quality has on their personal health and how to behave to avoid possible impacts. Furthermore the same pollutant concentration has not the same impact on all citizens. A healthy person does need other information than a patient with a respiratory disease. Again this stresses the effort of user-tailoring of information – this time related to the health state of the addressee.

As mentioned in chapter 3 MARQUIS uses different predefined user-profiles. For each of these profiles special tailored health information is associated with pollutant concentrations respectively AQIs. These health information texts are extracted from studies on short and long term effects of air pollutants on human health. Beyond the bare information on health there are behaviour advices how to avoid or minimise the personal risk.

	general public	respiratory diseased patients	medical professionals
ozone 120 – 179 g/m³	No harmful effects to human health expected.	Increase of reversible short term effects to human health (e.g. beginning irritation of the respiratory tract) is possible with ozone sensitive people. Please avoid continuous physical outdoor activity.	For all people (especially for elder men) even short-time expositions can lead to a higher frequency of hospital consultations.

Figure 4.4: Health information for different user profiles

4.3 Discussion of the course of day

Air quality is not static but is subject to temporal fluctuations. Thus the real-time information generated by MARQUIS for a measurement station might change enormously during the day. To provide comprehensive and understandable information on air quality to the general public these daily fluctuations have to be presented and explained.

Interesting situations in the daily distribution of pollutant concentrations are of course threshold exceedances. Thresholds for all classical air pollutants are defined by the European legislation (EC 1996). But there are also national or regional ones. Information on exceedances of regional or national thresholds are of course relevant only for citizens in this applied area. This is another example of MARQUIS user-tailoring– in this case according to the users' location.

In addition there might be other interesting situations in the distribution curve like extremes – maximum and minimum (in MARQUIS called: very important points – VIPs) and the difference between them or tendencies in the concentration curves (very important changes – VICs) (see Figure 4.5). E.g. if an asthma patient gets problems with his respiratory tract in the early afternoon a notice of a sharp raise of the ozone concentration might help him to understand better the effects of air pollution (in this case the concentration of ozone) on his personal health. Thus if there is a similar air pollution situation forecasted for the next day he can look ahead and protect himself. Besides he can adapt his own MARQUIS user profile to get informed if his personal pollution threshold is exceeded.

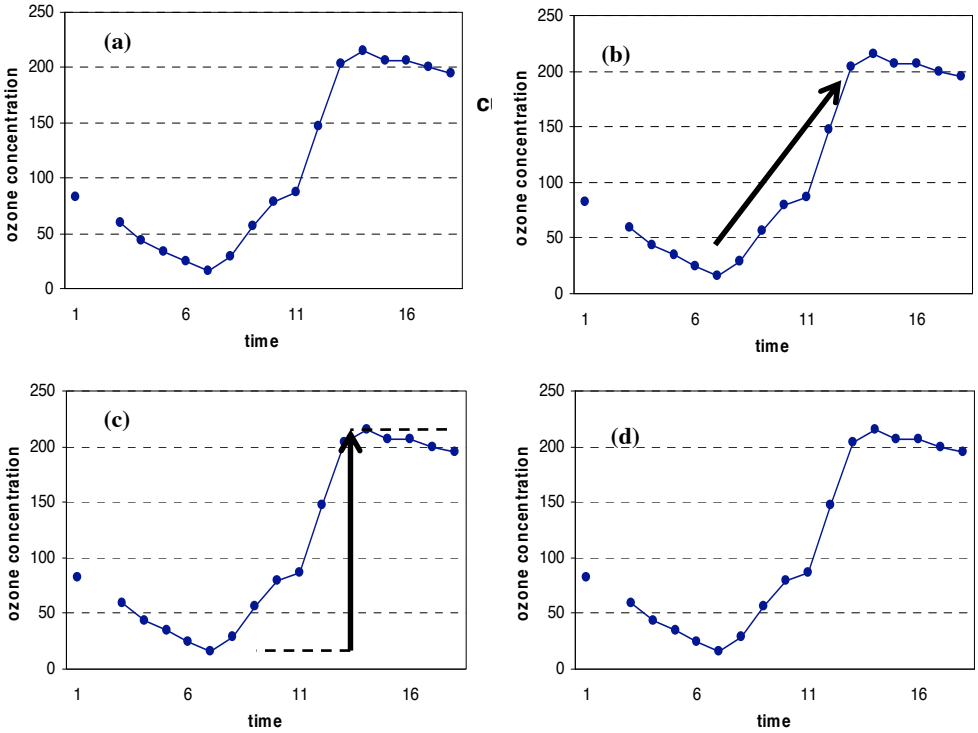

Figure 4.5: Discussion of the course-of-day for the ozone concentration (in $\mu g/m^3$) at the station Karlsruhe-NW, 12.6.2003, (a) very important points (VIPs), (b) very important changes (VICs), (c) deltas between VIPs, (d) threshold exceedance

But MARQUIS goes even behind the discussion of the air pollution course of day. It can give justifications for air quality situations or fluctuations such as meteorological conditions. So, high ozone concentrations are pulled together with high temperatures in summertime. The same is done with dropping particulate matter concentrations and precipitation. MARQUIS not only inform on air quality – it also tries to establish understanding for air quality.

4.4 Regional discussion

Air quality differs not only in time but also in space. Some few kilometres can change air quality situation a lot. In every day life citizens do not stay at the same location the whole day. In fact most of them are moving in a defined area like around their home, their workplace and shopping and leisure areas. MARQUIS provides in one-stop information on a whole area of interest. Comparisons between different cities are also made as well as comparisons between urban and rural areas.

The user profile of information brokers is also an important issue. A newspaper provides e.g. meteorological information for the area it covers. The air quality information has to cover the same area to be of

interest for them to publish. Thus it is possible to set up a special profile for each newspaper to meet its requirements.

5. Conclusions

To provide air quality information to general public in a comprehensive and understandable way there must be more than only raw data and general background information. The social, cultural and knowledge background differ so much among the possible addressees that information has to be tailored to each of them. MARQUIS took the approach of basic user-profiles which can be adapted by each user to its own special needs. To meet these needs an extensive interpretation and assessment of the raw data is necessary. This ensures that useful information is provided for different addressees.

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