Expert System for Campus Environment Indexing in Wireless Sensor Network

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***Abstract*— Wireless sensor network can deliver environment data in campus area as CO, NO2, HC, particulate matter, temperature, humidity, and luminous intensity to provide accurate realtime data. This realtime environment data is used for environment indexing accurately, and then can be developed in an expert system. This expert system collects input data from the sensor. This expert system will help giving the accurate input for campus authority to state and evaluate campus developing policy continuously. This expert system uses forward chaining method, PHP programming language and MySQL database.**

Keywords*—*expert system, campus environment, environment index, wireless sensor network, forward chaining

I. Introduction

Campus is one of the places for education. Students use campus not only for studying but also for developing talents. So that students can do learning maximally, good campus environment is required.

Now, primary environment issues that campus authority faced are climate changing mitigation and campus sustainability. World universities, including Indonesia, make an effort to decrease carbon emission, control and increase sustainable campus developing.

Continuously campus developing scheme involves 3 indicator aspects, environment, research, and society [1]. Those 3 aspects become a stake, interconnected, and multidimensional to actualize featured campus that consist of environment knowledge, using and managing efficient energy, research, and civitas academica awareness.

One of the metrics that used to evaluate campus developing is UI GreenMetric [2]. UI GreenMetric has 5 criterias, environment arrangement, cimlate changing mitigation and energy conservation, waste management, eco-friendly water conservation and transportation [3]. Doing evaluation method by descriptive and qualitative, score weighting and calculating. This metric evaluates the policy and campus' effort to actualize green campus. The assessed indicators are environment arranging and campus infrastructure related to electricity usage, the quantity of vehicles, energy saving device usage, renewable energy usage policy, the reduction of gas emissions policy, and transportation policy to limit the quantity of vehicles inside the campus.

Wireless sensor network (WSN) system is a system that can deliver environment data such as CO, NO2, HC particulate matter, temperature, humidity and luminous intensity. The data that determine index/score each parameter have to be accurate. Those parameters will give some indications that cause some results. The results need solutions and will be used as policy products. The effects of these policies have to be measured accurately.

One of the technologies that capable to determine and measure accurately is expert system. This expert system will be used to determine and give a meaningful information, such as healty enviroment index, to campus stakeholders from accurate data provided by environment sensor in WSN system. The information is then presented as web service than can be accessed using browser.

II. The Underlying Theory

A. Expert System

Expert system is system that trying to adopt human's knowledge into computer, so that computer can solve the problem like the experts do. Because of this system, common people can solve the complicated problem that actually can only be solved by the experts [4,5].

Expert system consists of 3 primary components, user interface, knowledge base and inference engine as depicted at Figure 1.

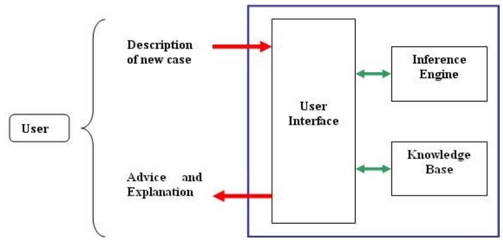


Figure 1. Block Diagram of Expert System

Expert system usually presents some certain questions until it can decide an object that matches with the informations. This is the part of high level specialization software trying to duplicate the function of certain expertise fields. This program act as consultant inside expert scope, as collected knowledge results from the experts[5].

B. *Wireless Sensor Network*

Wireless Sensor Network is a network composed by some node sensors that have sensing, wireless communication, and computing ability. A node sensor has 2 components, mote and sensor. Sensor always sticks to the mote. Mote is responsible to storage, computation and communication, meanwhile sensor is responsible to physic phenomenon sensing such as temperature, luminous, voice, vibration, et cetera. Node sensor collects data and process on network by data collected to the intermediate node before continue to the data center for analysis or further processing.

At first, the research about WSN is part of Distributed Sensor Network (DSN) program by Defense Advanced Research Projects Agency (DARPA) at 1980. At that moment, sensor was expensive and had relatively big size so the usage was limited only for military and state prominency. Now, there are many small size sensors with affordable price so can be used in wider applications.

In step with internet technology development, WSN then integrated in Internet of Things (IoT) concept, IP-based WSN. In this concept, each sensor has unique identity so dynamically join into a network, collaborated and cooperated efficiently [6].

III. Materials and Methods

When building a good software system, a mature design is required. A good and structured design should be suitable with the existing needs. Hence, in this expert system design, need analysis and structured design are necessary started from designing database, function to interface of system. An application made will consist of client and server which the client can be accessed through the mobile devices and the server can be accessed through web. A network is needed to operate the application of expert system as the system later is put is in a server. The system requirements consist of 2, functional and non-functional requirements.

1. Functional Requirements
   a. System can diagnose environment parameters such as CO, NO_2, HC, PM, humidity, temperature and luminous intensity.
   b. System has login feature for admin, environment expert and visitor, so not everyone can access the database.
   c. Admin and expert can manage the symptom data used as parameter input.
   d. Admin and expert can manage the result and solution data used as parameter output.
   e. Admin and expert can see the history sort by time.
2. Non-functional Requirements
   a. System must be user-friendly.
   b. System can be accessed from computer device using web browser.
   c. System has confirmation and notification features if user doing any data changing.

The specifications of the hardware used in building the expert system are listed as follows:

1. Notebook Intel® Core™ i5-2430M (2.4 Ghz)
2. 4 GB Memory (RAM)
3. 500 GB Hard disk

Meanwhile, the software used is listed as follows:

1. Windows 7 operating system
2. Apache
3. PHP MyAdmin and MySQL
4. Sublime Text 2
5. Google Chrome browser

IV. Results and Discussion

The first step of this expert system designing is creating database and tables. In this database, there are 12 tables as shown at Table 1.

Table 1. List of Tables in Database

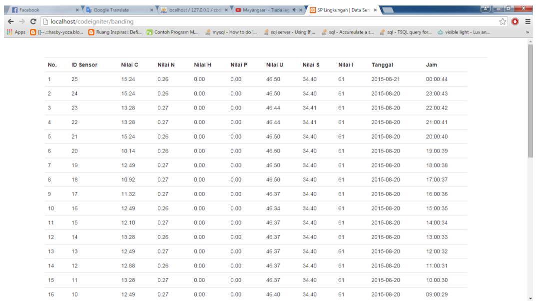
Tabel	Tindakan	Baris	Jenis	Penyortiran	Ukuran	Beban
input_data	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~0	InnoDB	latin1_swedish_ci	16 KB	-
input_sensor	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~25	InnoDB	latin1_swedish_ci	16 KB	-
parameter	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~7	InnoDB	latin1_swedish_ci	16 KB	-
tbl_c	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~4	InnoDB	latin1_swedish_ci	16 KB	-
tbl_h	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~4	InnoDB	latin1_swedish_ci	16 KB	-
tbl_i	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~4	InnoDB	latin1_swedish_ci	16 KB	-
tbl_n	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~4	InnoDB	latin1_swedish_ci	16 KB	-
tbl_p	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~4	InnoDB	latin1_swedish_ci	16 KB	-
tbl_s	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~4	InnoDB	latin1_swedish_ci	16 KB	-
tbl_u	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~4	InnoDB	latin1_swedish_ci	16 KB	-
user	Jelajahi Struktur Cari Tambahkan Kosongkan Hapus	~3	InnoDB	latin1_swedish_ci	16 KB	-
view_hasil	Jelajahi Struktur Cari Tambahkan Hapus	~0	Gambarkan	---	-	-
12 tabel	Jumlah	~2	InnoDB	latin1_swedish_ci	176 KB	0 B

In the parameter table, there are 7 parameters that sensor will store. The 7 parameters are given at Table 2.

Table 2. List of Parameters

Parameter ID	Parameter Name
C	Carbon monoxide
N	Nitrogen dioxide
H	Hidrocarbon
P	Particulate Matter
U	Humidity
S	Temperature
I	Luminous intensity

Figure 2 is the sample data from sensor that insert into input_data sensor table.



No.	ID Sensor	Nilai C	Nilai N	Nilai H	Nilai P	Nilai U	Nilai S	Nilai I	Tanggal	Jam
1	25	15.24	0.26	0.00	0.00	46.50	34.40	61	2015-08-21	00:00:44
2	24	15.24	0.26	0.00	0.00	46.50	34.40	61	2015-08-20	23:00:43
3	23	13.28	0.27	0.00	0.00	46.44	34.41	61	2015-08-20	22:00:42
4	22	13.28	0.27	0.00	0.00	46.44	34.41	61	2015-08-20	21:00:41
5	21	15.24	0.26	0.00	0.00	46.50	34.40	61	2015-08-20	20:00:40
6	20	10.14	0.26	0.00	0.00	46.50	34.40	61	2015-08-20	19:00:39
7	19	12.49	0.27	0.00	0.00	46.50	34.40	61	2015-08-20	18:00:38
8	18	10.92	0.27	0.00	0.00	46.50	34.40	61	2015-08-20	17:00:37
9	17	11.32	0.27	0.00	0.00	46.37	34.40	61	2015-08-20	16:00:36
10	16	12.49	0.26	0.00	0.00	46.34	34.40	61	2015-08-20	15:00:35
11	15	12.10	0.27	0.00	0.00	46.37	34.40	61	2015-08-20	14:00:34
12	14	13.28	0.26	0.00	0.00	46.37	34.40	61	2015-08-20	13:00:33
13	13	12.49	0.27	0.00	0.00	46.37	34.40	61	2015-08-20	12:00:32
14	12	12.88	0.26	0.00	0.00	46.37	34.40	61	2015-08-20	11:00:31
15	11	13.28	0.27	0.00	0.00	46.37	34.40	61	2015-08-20	10:00:30
16	10	12.49	0.27	0.00	0.00	46.40	34.40	61	2015-08-20	09:00:29

Figure 2. Sample Data

The 7 parameter indicators are inserted into each their tables (tbl_c, tbl_n, tbl_h, tbl_p, tbl_u, tbl_s, tbl_i) as depicted at Figure 3.

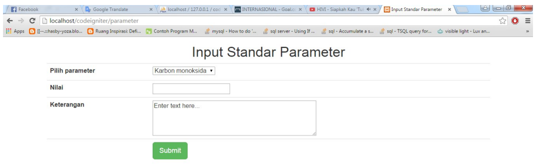


Figure 3. Input each Parameter Indicators

The dasboard where can edit or delete data is depicted at Figure4.

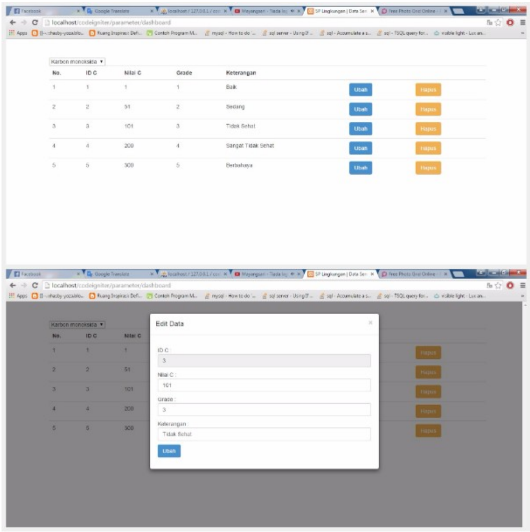


Figure 4. The Dashboard

According to **Keputusan Kepala Bapedal No. 107 Tahun 1997** about Calculation, Reporting and ISPU (Indeks Standar Pencemaran Udara) Information [7], given the index limit of each parameters displayed in a tabular as depicted at Table 3.

Table 3. ISPU Limit in International System of Units

Indeks Standar Pencemar Udara	24 jam PM_{10} µg/m³	24 jam SO_2 µg/m³	8 jam CO µg/m³	1 jam O_3 µg/m³	1 jam NO_2 µg/m³
50	50	80	5	120	(2)
100	150	365	10	235	(2)
200	350	800	17	400	1130
300	420	1600	34	800	2260
400	500	2100	46	1000	3000
500	600	2620	57.5	1200	3750

The way to measure daily index is also different. For C, N, H and I, accumulate input every 1 hour, meanwhile for P and U, calculate the average by (1).

$$\frac{2 \times data\,07.00 + data\,13.00 + data\,18.00}{4} \quad (1)$$

Then, daily index recalculate by (2).

$$I = \frac{Ia - Ib}{Xa - Xb}(Xx - Xb) + Ib \quad (2)$$

Where:

I = calculated ISPU

Ia = upper limit ISPU

Ib = lower limit ISPU

Xa = upper ambient

Xb = lower ambient

Xx = real ambient measurement result level

Aftter that, the calculated ISPU is compared with data in the ISPU limit table at Table 4.

Table 4. List of Number and Category of ISPU

Index	**Category**
1 – 50	Good
51 – 100	Medium
101 – 199	Poorly
200 – 299	Very Poorly
300 – more	Dangerous

Figure 5 and Figure 6 show the interface where system displays the output.

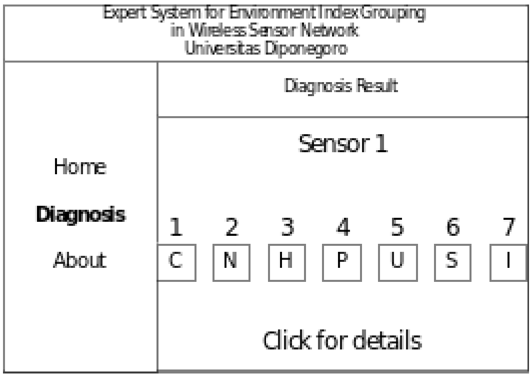


Figure 5. Output Interface

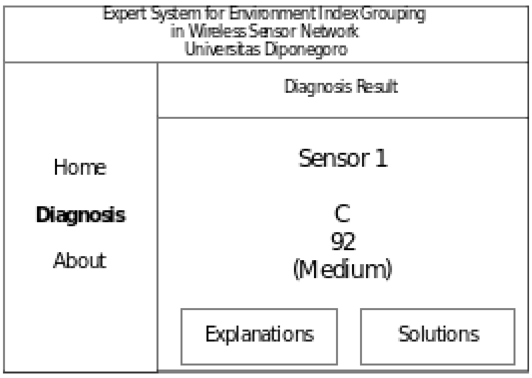


Figure 6. Output Interface (ii)

V. Conclusions

The expert system for environment index was developed for the web-based application to be accessible at anytime as long as the users brings the computer devices and internet connection is available. This expert system was developed using CodeIgniter in which supported with PHP language, using Bootstrap and CSS as its basic display that can be used for further needs. The 7 parameters that measured by sensor is chosen by its existences in the campus area. CO, NO_2 and HC are produced by vehicles' gasoline contamination, meanwhile PM, humidity, temperature and luminous intensity are produced by surrounding combustion activity. Based on the ISPU, there are 5 categories index that can be available to determine which category each parameters belong to and calculate by the given formula. For further research, it is suggested to conduct that the expert system to make it applicable in mobile device like Android.

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