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An Expert System for Selection of Sites for Location of Industries

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Abstract: All living creatures need air to survive. The number of pollution complaints received by the Department of Environment (DOE) has been rising steadily and has far exceeded other complaints; a few air pollutants can injure health, harm the environment and cause property damage. Due to shortage of manpower it is very difficult to verify that the developer actually complied with the approved Environmental Impact Assessment (EIA) guidelines. In (EIA) reports, the study to identify, predict and evaluate the impacts on the environment of any proposed project and to detail out the mitigating measures must be corrected out prior to the project approval and implementation. This study utilizes the application of a computer technology in the form of an expert system for the selection of industries in accordance to the air pollution index control. Some appropriate rules for structuring and implementing optimal air quality standards using CLIPS helps in the analysis and management of EIA information would also be examined.

Key words: Air pollution, industries, ES, CLIPS, EIA

]INTRODUCTION

Air is one of the important media for survival by living creatures on earth. Air is considered normal if more than 99.99% of volume consists only of four gas molecules, nitrogen made up of (about 79.9%), oxygen (about 19.94%), argon (about 0.84%) and carbon dioxide (about 0.03%) and about a dozen other constitutes are found in trace quantities[1]. Air pollution is associated with increased incidence of respiratory diseases as well as increased mortality due to pulmonary and cardiovascular diseases. One of the major components of photochemical air pollution is ozone (O_3). Ozone is produced by the reaction between nitrogen oxides and volatile organic compounds in a process catalyzed by ultraviolet light[2].

Optimization models for the management of air quality started in the late 1960s[3,4], but the differential equation based descriptive plume models began much earlier. Recent reviews of the optimization models are provided by many researchera[5-7].

Cooper *et al.*[7] reported the principal air quality issues of local, national and international concern that are discussed in increasing order of difficulty based on the number of different types of pollutants and problems in quantification of the risks the pollutants pose:

Stratospheric ozone depletion: This is due to relatively easily controllable class of trace gases-Ozone Depleting Chemicals or ODCs, principally Chloroflurocarbons (CFCs)-with relatively well quantified risks.

Criteria pollutants: Six common pollutants-ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), lead (Pb) and particulate matter less than 10 microns in size (PM10)-regulated since 1970 in the U.S. and presenting relatively well quantified risks.

Acid precipitation: Two relatively easily controllable classes of trace gases-oxides of nitrogen (NO_x) and oxides of sulfur (SO_x) with relatively well quantified risks.

Global warming and climate change: A few difficult to control trace gases-principally carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and CFCs-with highly uncertain risks;

Toxics or hazardous air pollutants (HAPS): Many types of gaseous chemicals and particles with uncertain risks. In Malaysia, EIA is required under section 34A[8], when integrated into the existing planning and decision-making machinery provides additional information towards better decision-making. The aim of EIA in Malaysia is to assess

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the overall impacts of development environment due to development projects. Based on 1995 Environmental Quality Report[8], air pollution was ranked first (69%), followed by water pollution (11%), noise pollution (6%) and others including increasing rapid land development (14%). Land development may affect the quality of air levels in the short term while in the long term, it may damage all the lives, industrial processes and other activities. Also EIA requires a large number of experts, finding a team expertise would be a major problem.

MATERIALS AND METHODS

Expert System (ES) has been chosen to organize part of the knowledge domain in air pollution from the EIA to non-expert users. This knowledge should support them in both the pre-construction and construction stages, as well as for predicting the potential impact and mitigating measures. The data used were collected from three main sources; from literature review, from DOE and from the expert in air pollution. Air quality checks were performed within a 2 km radius of the site directed by DOE to comply with the clean air regulation for the period 1995-2001. Sampling points must always be within the site and the average monitoring time of the Total Suspended Particulate (TSP) carried for a 24 h period, nitrogen dioxide (NO_2) for an average of 1 h and sulphur dioxide (SO_2) for an average of 1 h.

RESULTS AND DISCUSSION

The software CLIPS used is designed as a set of program unit is written in a CLIPS, which was designed at NASA/Johnson Space Center with the specific purpose of providing high probability, low cost and easy integration with the external system using C language to facilitate those objectives. CLIPS is an acronym for C-Language Integrated Production System forwarded chaining rule, directly integrated with the inference engine and wxCLIPS to provide a simple graphical font. Facts are the first component of a CLIPS system and rules are the second component of a CLIPS. A rule is divided into Left Hand Side (LHS) and a Right Hand Side (RHS). The LHS of a rule can be thought of as the IF part and the RHS can be thought as the THEN portion of work. Rules can have multiple patterns and actions. CLIPS is a productive development and delivery expert system tool which provides a complete environment for the construction of rule and/or object based expert system.

Choice of industries: For the effect of TSP and dust on project area, the research concentrates on TSP and its effect. Adverse health effects from particulate in the atmosphere have been observed at concentrations exceeding 100 μg m^{-3}. This may aggregate bronchitis, emphysema and cardiovascular disease and also cause serious visibility problems[9]. Guidelines issued by WHO suggest that the exposure limit consistent with the protection of human health should be 100-150 μg m^{-3} for 24 h and 40-60 μg m^{-3} annually. Particulate, which is more important to human health, is generated from the burning as well as from wind movement. Dust, which is taken to be particulate matter whose level of 10 or more is regarded hazardous when compared to suspended particulate. To decide whether to construct an industry based on the value of TSP that is, suggested by WHO[10] for human and from EIA reports (Table 1).

Table 1: Type of industries for certain values of TSP

TSP value (μg m^{-3})	Type of allowed industries
0-80	All type of industries
81-150	Only light industries
150-259	Only heavy industries
≥260	No industries allowed

The annual concentration of TSP is generally high in industrial and heavy traffic areas due to its emission from the factories and motor vehicles. The annual concentration of dust fallout is generally high in commercialize and residential areas but low in industrial areas. Table 2 explains the source of air pollution for industrial areas only, the sampling point for the pollutants, which are either TSP for 24 h averaging time, SO_x and NO_x for 1h averaging period and end with expected air pollution level due to development for the period of 1995-2001.

From these results it can be said that different prescribed activities have different existing environment which in turn has different air pollution levels with different potential impacts and mitigating measures.

System description: The air pollution expert system for selecting the type of industries consists of the following parts (a) the Knowledge-Base (KB), containing the expertise in the industrial areas codified by the means of a rule, (b) the Working Memory (WM), allowing the processing of all input data and problem facts discovered during the session, © the Inference Engine (IE), allowing the users as an interactive consultation of the KB, specifying and progressively refining the problem definition, in order to lead to the prediction and solution and (d) a Knowledge Based Check Tool (KBCT), to help the expert to compile and verify new sets of rules for validation and updating (Fig. 1).

Expert system rules: Through the studies, the knowledge was translated into four sets of rules which are (1) choices

Table 2: Source of air pollution due to development (Source DOE 1995-2001)

Existing land use	Sources of air pollution	Sampling point	Expected air pollution level
Industrial area	Disposal of solid particulate Raw material transfer Finished material movement Burning of waste matters Traffic circulation	Within the site	Depending on the type of industries used. The level either Good, Moderate, or Hazardous.

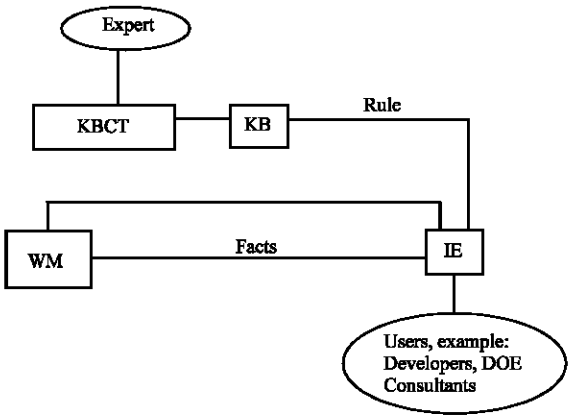

Fig. 1: Air pollution structure

```
IF selection is 0
THEN the project type is industrial area
IF the selection is 1
THEN the project type is housing scheme.

The rule in CLIPS language;
(bind ?select (radio-box-get-selection ?id))
(If (eq ?select 0) then (bind ?*pt* 1))
(If (eq ?select 1) then (bind ?*pt* 2))
```

Fig. 2: Example of the rules for an existing environment

```
IF selection is 0
THEN potential impact is pre-construction
IF the selection is 1
THEN potential impact is in construction stage

The rule in CLIPS language;
(bind ?select (radio-box-get-selection ?id))
(If (eq ?select 0) then (bind ?*pi* 1))
(If (eq ?select 1) then (bind ?*pi* 2))
```

Fig. 3: Example of the rules for potential impacts

of an existing environment, (2) potential impacts, (3) mitigating measures and (4) pollutant level, (5) decision- selection of type of industries.

Rules for choices of existing environment: The rule will be in a form of radio-box and the meaning of the rule is that if the selection is number 1, then the project type (pt) is industrial area that is bind by 1; if the selection is number 2, then the (pt) is housing scheme, etc. the information is converted into ES rules in a simple language (Fig. 2).

```
IF selection is 0
THEN potential impact is pre-construction
IF the selection is 1
THEN potential impact is in construction stage

The rule in CLIPS language;
(bind ?select (radio-box-get-selection ?id))
(If (eq ?select 0) then (bind ?*mm* 1))
(If (eq ?select 1) then (bind ?*mm* 2))
```

Fig. 4: Example of the rules for mitigating measures

```
IF the project type is in industrial area AND potential is in the
pre-construction stage AND the mitigating measures is in the
pre-construction.
THEN get the result - recommendations

The rule in CLIPS language;
(deffunction result-proc(?id)
 (If (and (eq ?*pt*1)(eq?*pi*1)(eq?*mm1)) then
(bind? *canvas* (canvas-create?**frame 430 0 128 128))
(bind? *bitmap* (bitmap-load-from-file"factory.bmp))
(window-add-callback? *canvas* OnPaint on-paint)
(text-window-load-file? *text-win* "ft1.text"))
(If( and (eq? *pt 1) (eq? *pi* 2) (eq? mm*2)) then
(text-window-load-file? *text-win* "ft2.txt"))
(If (and (eq? * *pt*1) (eq? *pi*3) (eq? *mm* 3)) then
(text-window-load-file? *text-win* "ft3.txt"))
```

Fig. 5: Example of the rules for pollutant level

Rules for potential impact: Referring to the results of the potential impacts for each existing environment and specific industry during pre-construction stage, construction stage and post-construction stage, the information was converted into ES rules (Fig. 3).

Rules for mitigating measures: Referring to the results of mitigating measures for each existing environment and specific industry during pre-construction stage, construction stage and post-construction stage, the information is converted into ES rules (Fig. 4).

Rules on pollutant levels: Based on the DOE, from 1995-2001 Industrial areas have an annual mean concentration TSP of 92 $\mu g\ m^{-3}$, the highest level was at Pasir Gudang (186 $\mu g\ m^{-3}$), with the minimum level of 71 $\mu g\ m^{-3}$ and the maximum of 267 $\mu g\ m^{-3}$. The information was converted into the ES rules in a simple language (Fig. 5).

Rules on choices of the industries: The information from Table 1 and Malaysia Air pollution Index (API) was converted into ES rules shown in Fig. 6 and 7.

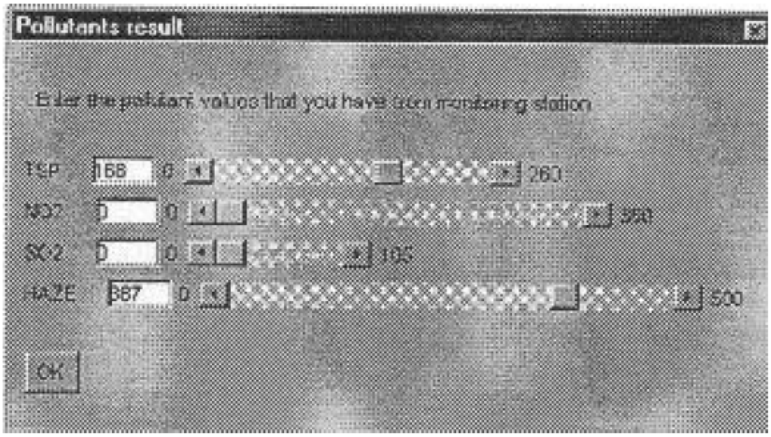

Fig. 6: Selection of industries based on pollutants level

IF the TSP level is between 0 and or equal 80
THEN all industries allowed
IF the TSP level between 81 and or equal 150
THEN light industries allowed
IF the TSP level between 151 and or equal 259
THEN heavy industries allowed
IF the TSP level greater than or equal 260
THEN no industries allowed

The rule in CLIPS language;

```
(deffunction tsp(?id)
 (bind? Select (slider-get-value ?id))
(If (and (>= ?select 0) (<= ?select 80))
(then (bind ?*tsptest* 1))
(If (and (>= ?select 81) (<= ?select 150))
(then (bind ?*tsptest* 2))
(If (and (>= ?select 151) (<= ?select 260))
(then (bind ?*tsptest* 3))
(If (and (>= ?select 260)
(then (bind ?*tsptest* 4)))
```

Fig. 7: Example of the rules for choices of industries

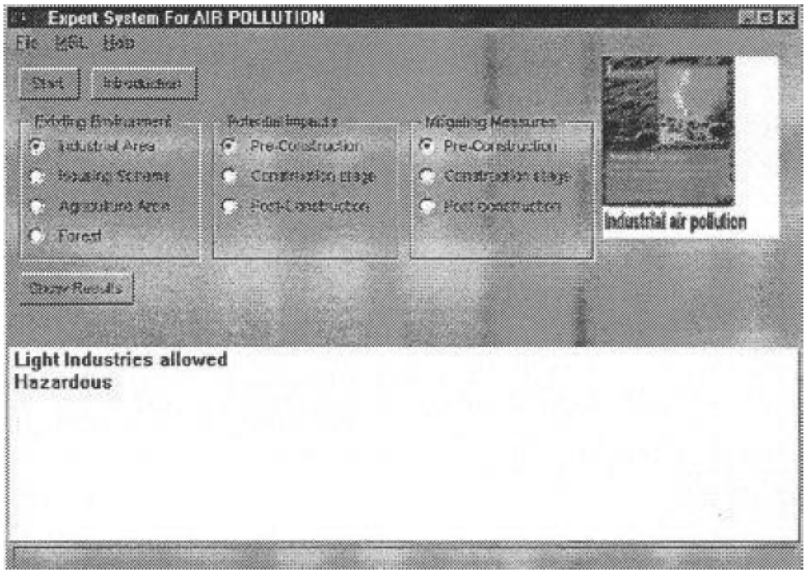

Fig. 8: Air pollution session screen

Consultation: An example: Assuming that the problem of the user is to build an industry in an existing in an industrial area and the TSP from the monitoring station is 168 μg m^{-3}. The user wants to predict the type of industries that can be selected.

The user specifies step by step the scenario of constructive the system, guided by a series of choices from radio boxes (Fig. 8). At each consultation step, the user can choose from the system, existing environment, project activities, potential impact during the construction stage and mitigating measures. The system automatically gives an immediate result as shown in Fig. 8.

CONCLUSIONS

In validating the choices of industries due to development using ES, it is based on studying air pollution from external agencies like WHO, USEPA, DOE, developer, the input data are of four types of the existing environment, the pollutant level and the degree of haze. The data then validated and corrected using statistical analysis for the pollutants, which are TSP, NO_2 and So_x.

In some systems the database gives a description data of the project description and environment and mainly used by the EIA experts[11,12]. In this study the system database was made up of numeric, text, maps, table and figures, as well as knowledge information about expected potential impact, mitigating measure and pollutant levels used by EIA experts and non-expert in the development stage.

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