DESIGN OF AN EXPERT SYSTEM ANALYSING PROPERTIES OF VISUAL PERCEPT

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Visual displays play the key-role in almost every human-controlled system. In the process of development of such systems industrial designers need to design legible visual displays in ergonomic sense.

Readability of visual display can be affected by many factors including its position, the size of graphic details and also by visual defects of a man. At recent time it is possible to get some of visual displays properties using a computational modelling. The modelling is applicable, for example, to used font size or to the speed of movable parts of display determination ([3], [8], [9]). But computational models cannot involve all the substantial factors, which have an indispensable effect to the readability of visual displays, especially more complex factors. Position of stimulus created by a visual display on the human retina affects an ability of recognizing the shape, the colour and the movement, for example. This and similar factors can be taken into account by knowledge modelling, by an expert system. The intersection of these two types of modelling – the computational modelling and the knowledge modelling – can be termed as a hybrid modelling.

This paper is concerned with design of an expert system which is suitable for integration into the hybrid model.

Key words: *expert system, ergonomics, display, readability*

1. Introduction

The described expert system is part of project focused on creation of hybrid model describing properties of visual displays. The hybrid model is realized as software and it is determined for designers of display systems (system of displays on a gauge board for example).

The software uses a graphic interface, where a user can define properties of displays and properties of a man. Output of the software is given in a numerical format (size of substantial detail, optimal speeds of movement etc.) and in a text format. The text data output of the expert system signalizes properties and abilities of the visual percept (*'the display is too near, eye cannot accommodate and percept will be blurred'* etc.). The numerical output is the result of the computational modelling of the hybrid model. This structure is shown in the Figure 1.

1.1. Expert system

Expert systems – also known as knowledge-based systems – fall within the field of an artificial intelligence. They are used in medicine, control processes, for analyzing defects and similar applications. Expert systems substitute knowledge and cogitation of a human expert

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in a specific problematic. From the user point of view it is a computer program which asks the user and dependently on the answers chose other questions until it reaches the goal.

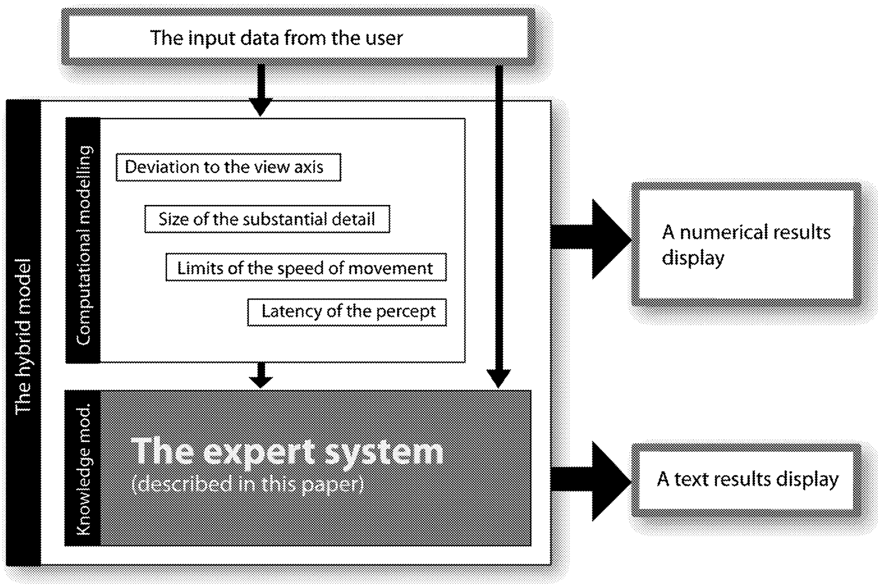

Fig.1: Diagram of the hybrid model

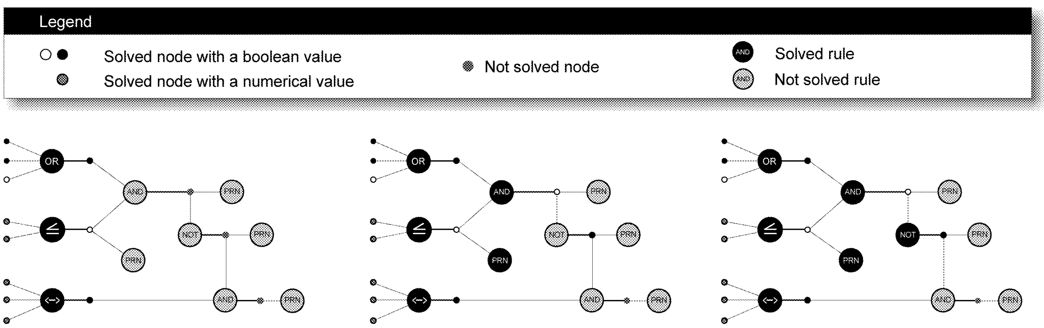

Fig.2: The second, third and the fourth iteration of an inference engine with the forward-chaining

Main parts of an expert system are the inference engine (IE), the rule-base and the input data-base. IE is the software itself and it takes care about running all the expert system. *'Rule base is the passive data structure, which contains generally known knowledge and information about patterns and rules in a specific problematic'* [2]. Also it is a structure, which is not written as a part of the code of the software but is created separately by an expert engineer. The rule-base is combination of rules, nodes and their linking, as can be seen in the Figure 2. Input data base is a list of values, which acts as an input data for expert system. Generally these are user answers to the expert system questions.

2. Design of the expert system

2.1. The aim of the expert system

The software is aimed to define visual displays properties. A user of the software defines the properties of the eyes and vision (position, orientation, visual acuity etc) and properties of the list of visual displays (position, orientation, contrast etc.). When any change of properties occur the hybrid model is activated and results for the specific display are shown. Imagine a situation when the user in the user interface selects the display and move it to another position. While changing the display position the hybrid model is repetitively activated and user can read output data (preffered size of type or difficulties with visual percept for example) for the selected display in a real-time.

2.2. Specific points of the expert system

If the hybrid model is activated when any of properties is changed then it stands to reason that IE can not stop its process for asking the user. Thus, input data-base has to been created before IE starts. This is the first specific point of this system. The next specific point is that nodes are able to carry Boolean values (true or false) or numerical values. The last specific point is that IE is capable to solve more types of rules in an addition to the standard set of rules (AND/OR/NOT).

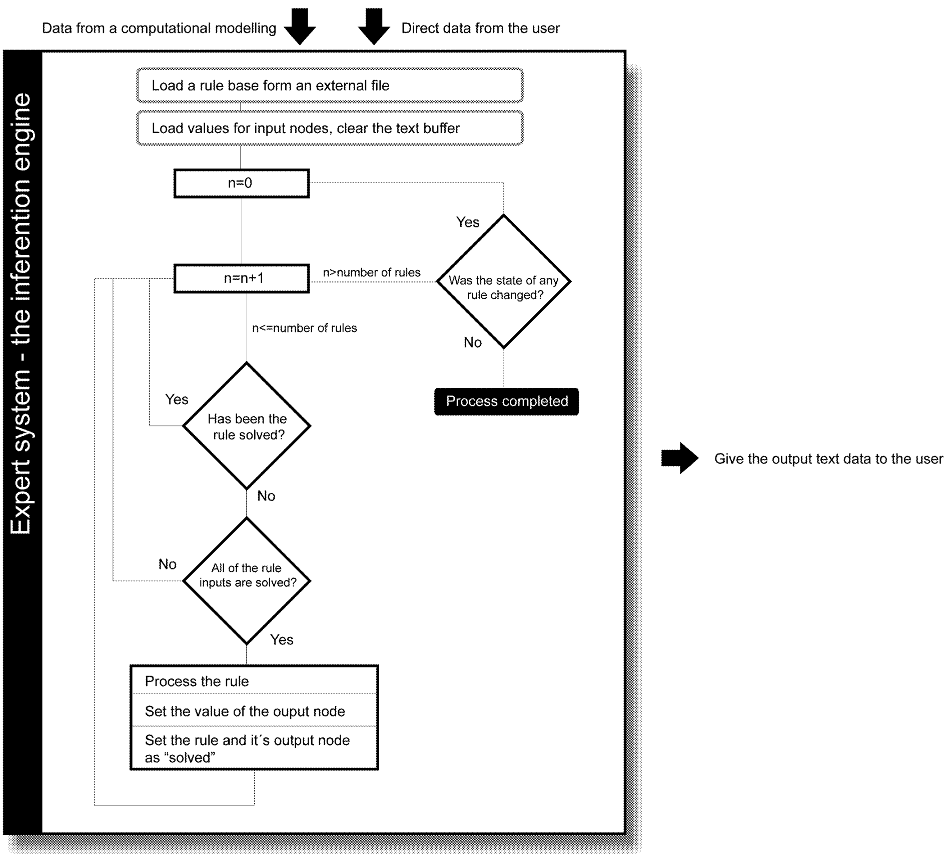

Fig.3: The flow-process diagram of the inference engine

2.3. Design of the inference engine (IE)

The purpose of IE is to find a goal from an included data. At the first it has to load the rule-base and the input data-base. After that IE tries to find a goal by specific strategy – in this case by forward chaining.

In the Figure 3 is shown the algorithm of the inference engine. IE loads the rule-base and the input data-base. Then it clears the text buffer and values in all nodes. After that it loads the input data- base and these values are saved to 'input nodes'. IE searches all of the rules and if the rule is suitable for solving (i.e. all of the rule inputs have been already processed) it is solved. The output value is set to the output node of the rule. This process is looped again until there is no change in the rule-base. When the IE reaches this state the processing is completed and output data can be displayed to the user.

2.4. Design of input data-base

In our case the input data-base is created from numerical and Boolean results of computational modelling and from numerical values defined by a user.

It is possible to transfer each variable from computational modelling to the expert system. The reduced list of variables used by an implicit rule-base is shown in the Table 1.

Variable	**Count and Data type**
Distance to the right and the left eye	2 × float
Horizontal, vertical and total deviation to the view axis	6 × float
Presence in the maximal field of view	2 × boolean
Disparation of images on retina	1 × float
Contrast ratio of foreground and background of the display	1 × float

Tab.1: The reduced list of input variables used by the implicit rule-base

The influence of other substantial variables, like visual acuity or deviation to the normal of the display etc., is covered in computational modelling in the first part of hybrid model.

Expert engineer is allowed to define new nodes with numeric or Boolean data. This kind of situation is shown in the Figure 4. Actual value of disparation (Figure 4, bottom-left) is compared with disparation limit (Figure 4, bottom-middle). The limit is acquired from physiology of vision [17].

2.5. Design of the rules for the rule-base

The rule-base is composed of the list of rules, nodes and links between nodes and rules. Generally this structure is called the 'AND/OR web'. Rule-base for a presented hybrid model needs some unusual specifics. Imagine situation when we need to check the distance of the display to an eye. When the distance is too short then eye is not able to accommodate and percept will be blurred. If the expert engineer needs to model such a situation, then additional relation rules have to be defined. Also, IE needs to read and write numerical values into the nodes. Thus nodes in presented expert system are capable of carrying both numerical and Boolean values.

The purpose of this expert system is to describe the properties of visual percept and to detect adverse circumstances. The goal of the expert system is not only 'the visual display is readable' even it could be useful. In the concern of a user is more detailed information as 'the shape of the stimulus can not be read' or 'stimulus leads to a diplopic percept'. For this purpose is created specific rule (named 'PRN'). When the PRN rule activated IE adds a predefined text message to the text buffer. The list of types of rules which can be used with this inference engine is shown in the Table 2.

Rule type	**Description**
NOT	Logic negation
AND	Logic multiply – conjunction $\wedge$
OR	Logic addition – disjunction $\vee$
<, >, =, >=, <=, =/=	Relation operators
(–), <–>	Relation – tests the value within defined range
PRN	Save a predefined message into the text buffer

Tab.2: The list of available rule types

2.6. Filling the rule-base

The rule base consists of interconnected rules and nodes. The rule- base is created in the specific-made editor. The user (knowledge engineer) can place rules and nodes on the working space. With the help of a mouse pointer user can connect or disconnect nodes to rules and define properties of rules. The position of rules and nodes has no effect to functionality of rule-base; it serves only for lucidity of the rule-base. The rule-base can be saved to a single file and can be loaded into the software for defining of properties of visual displays.

2.7. Design of the implicit rule-base

The implicit rule-base is aimed to extend numerical data from the computational part of the hybrid model. Areas not suitable for computational modelling are covered by the implicit rule-base. The expert system provides information to the user about status of visual percept :

- Is it possible to accommodate selected display? If not the percept will be blurred.
- Is the percept in the foveal area of both eyes? If not the percept cannot use red/green oponenci. Means the display cannot raise attention by switching color from red to green.
- Is disparation of images in disparation limits? If not the percept will be diplopic and the percept of shape will be incorrect.
- Is the contrast ratio above the lowest acceptable limit? If not light conditions or size of graphic details have to be changed.
- Is the display in the field of view? This condition is useful with large number of displays

The Figure 4 shows the rule-base in the way which is shown to the user in the rule-base editor. At the left side in the column are placed nodes of the input data-base. There is a possibility to test the rule-base in the rule-base editor and Figure 4 shows the state after fourth (and the last too) iteration. After the fourth iteration the inference engine is stopped and the user can read this text output :

'Display is in the field of view of both eyes. Display can be accommodated. Stereopsy is possible. Colour percept based on red/green oponenci is possible. The position of visual display is suitable. All of the visual percept channels can be used'

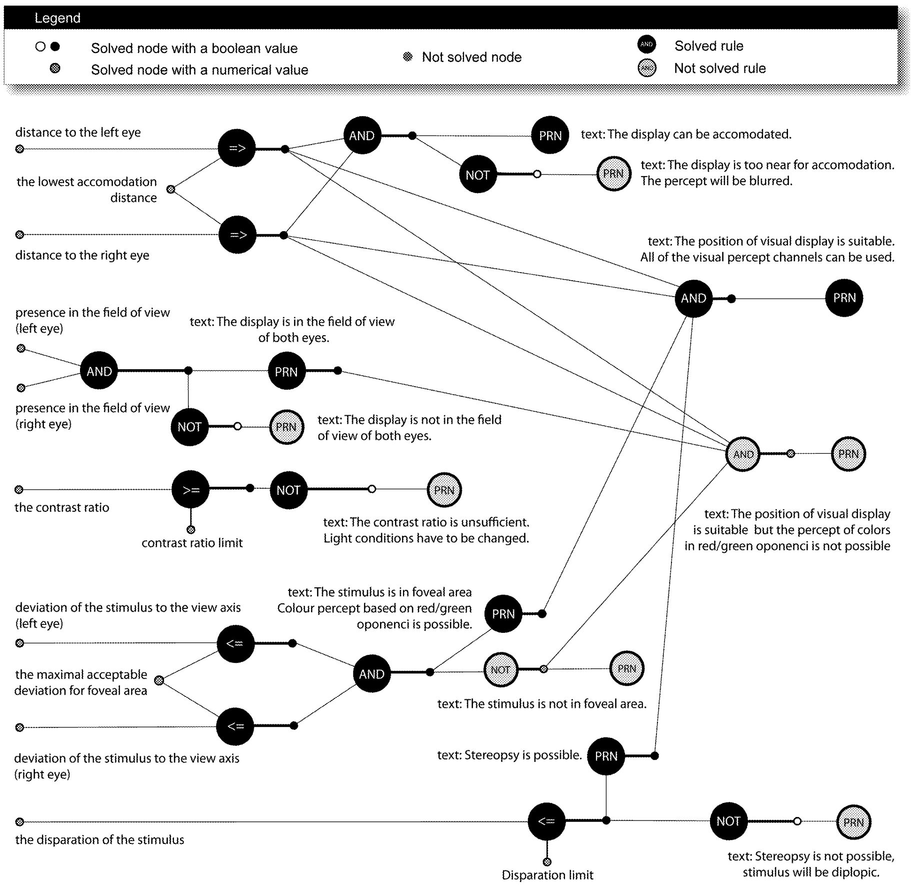

Fig.4: The implicit rule-base; on the left side are placed nodes of the input data-base

3. Discussion

3.1. Using of fuzzy logic

Some of expert systems use a fuzzy logic. This type of logic uses not only true or false statements but also allow evaluation of the statement as 'very right' or 'nearly false'. The using of fuzzy logic in presented expert system would be useful. In such a case the user would obtain the result 'the visual display is hardly readable' instead 'the visual display is not readable'. On the other hand using of fuzzy logic is conditioned by knowledge of related weight-functions. Level of knowledge in problematic can not describe those functions. Thus presented IE cannot work with fuzzy logic.

3.2. Method of reasoning

Expert systems use two types of reasoning – forward chaining and backward chaining. Metaphorically it is the direction in which is the AND/OR web solved. This expert system search conditions and tells what the visual percept will be like. For example if the stimulus is outside the central fovea then the expert system should give the information about lower sensitivity in red-green oponenci. This type of task is suitable for forward chaining.

Backward chaining looks like this: user sets the goal 'this display is red/green LED. Where should it be placed?'. On such a question there is unlimited number of answers. The user is forced to specify more conditions and run the process again. Backward chaining can be useful in such an application. The problem is that with usage of the backward chaining program code is more complicated and using of the software is more complicated too.

This is reason why only forward chaining, suitable for specified type of task, is used in the inference engine.

3.3. Possibilities of extending the expert system

The expert system can be extended for additional types of rules, specifically for rules with arithmetic operators. Such approach could lead to transfer of the computational modelling into the expert system. This means among others transfer of the computational model from unchangeable form (as a part of program code) to easily changeable form of the rule-base.

4. Conclusion

The inference engine is created and implemented into the software for defining of visual displays properties. The created expert system is aimed to find an attributes of the visual percept based on a specified visual display.

One of the advantages is that software can load different rule-bases into the hybrid model. For example: if the user needs to design system of visual displays according to Human Factors Design Standard [1] it is possible to create new rule-base and load it into the hybrid model. After defining of initial properties of displays and a man, the user can execute a hybrid model for the whole system and read the exported report. In the Figure 5 is shown an example of such AND/OR web based on a part of Human Factors Design Standard [1].

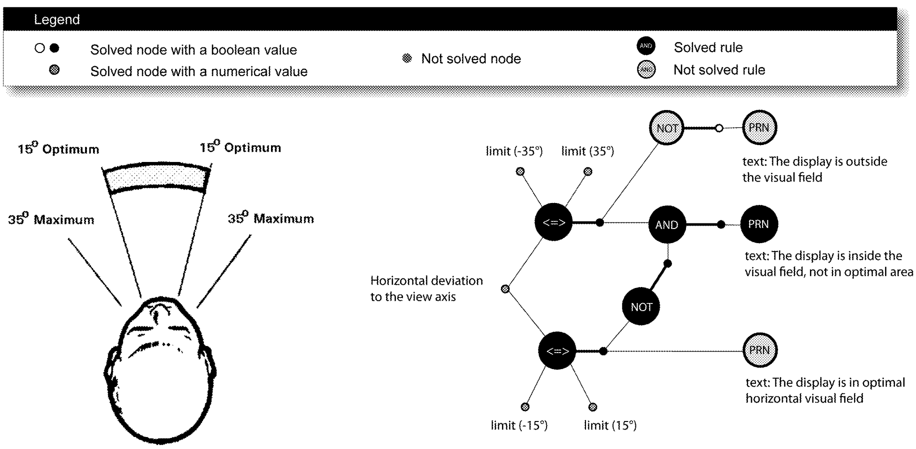

Fig.5: The optimum horizontal visual field [1] (left) and corresponding AND/OR web

Designed expert system is supposed to work as a part of the hybrid model, mentioned in the introduction. **Thanks to its architecture it can also run independently.**

Inference engine is able to process rules that can stop its running and keep waiting for input from the user. This situation is native to expert systems, but it is not allowed in our hybrid model. Outside the hybrid model the inference engine is allowed to work in this more standard way. Thus it can be used outside the hybrid model for example in analysing of disease or in the analysing of machine defects.

4.1. Future progression

The complete hybrid model is used in upcoming research project of Evektor s. s r.o. in collaboration with some other European companies. The project will start in the beginning of 2009.

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