Visualization of the information for reducing the cognitive work load for Harvester Machine Operators. Complex Interaction in Specialized Vehicles.

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Abstract
This project proposes a new way of visualizing the necessary information for operating a Harvester Machine. The final aim is to demonstrate how the arrangement of the information to be handled while operating the machine and the way this is visualized, make easier the control of the machine and reduce the stress loads for the operator. The Harvester machines are used for felling, delimbing and cutting trees into predetermined lengths. The control layout in the cabin comprises computer displays, traditional control panels and two joysticks for controlling the crane arm and the cutting head. Contextual inquiry and interviews were done during the research stage of the project in order to find the main causing factors of the stress situation while making decisions as a harvester machine operator. The operator needs to compare numerical values on the screen and check information on the forest at the same time before making a decision. Technologies such as head-up display [10] and eyes tracking system [11] take part in the final solution, for supporting the final concept and make the new way of human-computer interaction possible and effective. All the content and the information is divided and prioritized in levels according to the importance and frequency of use.

Keywords
Harvester Machine, visualization of the information, head-up displays, human machine interaction, eyes tracking system.

Introduction
The Komatsu project has been done by the first year's students of the Master Program in Interaction Design at the Umeå Institute of Design as part of the work requested during the first semester of this programme, fall 2008. The time available for carrying out the project was 10 weeks.

Figure 1. Harvester Machine Valmet 941.1 Komatsu Forest.

The harvester machine on matter is the Valmet 941.1 (figure 1), which utilizes the MaxiXplorer software as an interface between the operator and the system. For operating specialized commercial vehicles it is necessary to combine driving and maneuvering with other tasks such as excavating, moving logs or forestry work [1]. Today, the operator is also responsible for handling and increasing the amount of information while driving and maneuvering the machine. These additional tasks demand a high cognitive work load and extensive training is often required to master the complex modes of interaction.

This project focuses on the study of man-machine interaction in forestry logging harvesters and the approach of the research work on this project is user centered. By means of this specific type of research, the aim is to prove that the way of visualizing the information necessary while working it is really important and it is directly proportional to the time the operator spends in making a decision. Since the operator has to make several decisions in the process of logging a tree, if the final proposal make this process easier can reduce considerably the time for performing the mentioned task.

Several design research methods were used in order to find and identify the design opportunity to work on. Relevant aspects were considered for being included in the research stage in order to cover the majority of the necessary information for the development of the project. Information about different topics such as cognitive ergonomics, learning process, perception, task analysis and anthropometrics resulted very valuable for the project.

Research Methods
According to Dan Saffer, design research has many methods, drawn from other disciplines or created by designers over the years. These methods can be roughly divided into three categories: observations, interviews, and activities [2]. The kind of observation method that was used in this project was the one known as "Contextual Inquiry", which involves going to the subject's location and asking questions about their behaviors, asking opinions about the machine functionality and previous experiences with it. Afterwards, I was able to make interviews to some of the operators I visited in a different place outside the machine (figure 2).

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Figure 2.Contextual Inquiry with Dennis the operator.

These research activities represented the most valuable stage in the research phase, since the approach of the project is to apply the concepts of User Centered Design and Participatory design based on the work carried out by Buur & Bødker [3]. Different techniques were used for collecting the information of these visits. The observations and interviews were recorded in order to have all the possible details [4,5,6]. Later on the ideation stage, all the data collected in videos was reviewed and analyzed again to find the design opportunities.

Other complementary techniques were carried out during the observations such as taking still pictures, observing context issues that cannot be recorded on the video (vibrations, odors, weather) and taking field notes [2].

Conceptualization

Since the aim of the objective is to bring a benefit for the operator and improve the interaction with the machine he operates, a very important part of the project was the analysis of the observations and interviews to better understand how the user behaves while working with the machine and how the user manage and process the content. These results led us to define the areas to work on.

1. Arrangement of the information
The sources of visual input are too far from each other, this represents that the operator have to look at different points while performing a task (e.g. looking at the forest and screen at the same time).

These changes of focusing provoke problems in concentration and a delay in making decisions. The operator has to check the assortment on the screen almost at the same time he is looking for damages on the tree. It is difficult for the operator to check the quality of the tree in a normal situation because of the tree's shape, but it is even more difficult if they have to check data on the screen simultaneously. If the operator finds damages on the tree, he has to change the quality immediately; otherwise the log to cut is going to be useless because it doesn't correspond to the quality set it in the price list. The toughest part is that he has to check again the tree and the screen just to be sure that the length and the assortment suggested by the system, are going to fit in the quality area on the tree.

2. Prioritizing the information
Prioritize the information displayed on the screen is definitely important to propose the new arrangement of the information. This arrangement must be based in the frequency of use as well as the level of importance of each data displayed on the screen.

3. Overload of information on the screen
It is not necessary to have a lot of information always visible, it is better just have the information when it is need it.
Avoiding extra information on the screen represents less distractions for the operator and produces a high level of concentration while performing a task.

4. Difficulty to read numbers and process them
The fact that all the data displayed on the screen is showed in numbers represents more difficulty for the operator to understand it and it takes more time to read in comparison with more graphic visualization [9].

5. Lack of differentiation of elements in the graphic user interface
The elements on the graphic interface look like the same. They all are based in the same box outline and they all use numerical values [7]. The only data is presented graphically is the length of the log and the tree species (different colors according to the specie).

Analysis of the content

A more detailed analysis was done to break down all the information displayed on the screen and define exactly, what are the elements that should be available for the operator and in what situations.

The information was classified by dividing it in four main groups, according to the frequency of use and the level of importance for the working process:

1. High frequency of use and high level of importance. Main information.
2. Few times used and high level of importance. Information about the status of the machine
3. Frequently used and low level of importance. GPS, communication devices, etc.
4. Seldom used and low level of importance. Settings menu

Final result

On the final proposal, the interface of the machine is completely changed. The previous screen for displaying the information was replaced for a Head-Up display for presenting the data without requiring the user to look away from his or her usual viewpoint [10]. A new dashboard for showing the content in different levels to the operator was designed (figure 4).

Since the information is now split up in different areas, the final result proposes the use of an eyes tracking system for controlling the moment when the information needs to be displayed. If the system knows where the operator is looking at, the information only will be showed when the operator needs it.

According to the analysis of the content done previously, the information was divided in four groups. Each group of information has different designed areas either on the HDU or on the dashboard, as well different behaviors and features.

Main information / Level one of information
The group number one, which contains all the main information necessary for executing the tasks of logging the trees, is the only one that is visible all the time while doing this task. The information is showed in the same visual field of the operator (HDU). This means that he does not to look in two different places. On the other hand all the information showed in the interface is displayed in a graphic way instead of numerical values. This fact makes the operator executes the comparisons of the values in a faster way and requiring less mental effort (fig. 3).

Figure 3. Visualization of the main information on the head-up display.

According to the research the previous values were showed in numbers on the previous interface. In this proposal, instead of comparing numbers the operator just compare graphics placed on his main visual work area.

As we can see in the figure 3, the operator just see the information he needs at the moment. All the information that belongs to another group of information is hidden to avoid distracting visual noise.

For visualizing the information in the groups number two, three and four; the operator has to press the assigned button for activating the menus on the joysticks and then look at the area where the specific group of information is placed. It is important to mention that, if the operator does not press the button for visualize the hidden information, it does not matter if he looks at this area in the windshield, the menu will not show up. This information is not visible unless the operator wants to see it.

Status of the machine information / Level two of information
Since the previous screen is no longer in the cabin, there is an available space on the same place for situating the information belonging to level two and an eyes reader, an important element of the eyes tracking system [11] .

The proposed dashboard (figure 4) apart of containing the eyes reader, it contains the indicators of the status of the machine. Such indicators as fuel engage, temperature engage, oil engage, engine temperature engage are located here. The indicators about the driving direction, speed, door open, leveling system, ladder out, parking brake, etc., are also located on the dashboard.

Figure 4. Final proposal of the dashboard. It integrates several elements such as on-off button, contrast controls of the head-up display and indicators of the status of the machine.

All the information on the dashboard is situated a little closer than the information in group three and four. If an alert occurs the operator's eyes will perceive it faster because is situated in the middle vision field of the operator glance when he is looking at the front while working [8].

Frequent functions / Level three of information
This menu contains the functions the user needs to check frequently while he is not cutting the logs. These menus include shift timer, level of productivity of the day, matrix, cellphone, e-mail and gps function.

This menu is located in the top part of the windshield, what means that if the operator is cutting logs, he is receiving information in the central part of the windshield (central vision of the operator) and the hidden menu remains hidden (figure 5).

In case there is a notification about a special event in one of these functions, a visual and auditory alarm will occur on the peripheral vision.

Depending on the level of importance of each alarm such aspects as the time, sound, level of movement and intensity will change.For example, an alarm about the gps map will be more intense than a notification of receiving an e-mail.

Figure 5. Visualization of the machine information (group 3) on the head-up display.

Settings menu / Level four of information
Information about the settings menu such as machine settings, head settings, report, portal, tools, detailed status of the levels, calibration and administration belong to this category (figure 6).

The frequency of use of these elements is much less than the information in the previous groups. Because of this, the location where this information was placed is further from the central vision than the others.

Even though the previous group and the settings menu are in the same visual area, the treatment of each icons is very different. The icons on the setting menu are monocromatic and drawed with outlines. The ones in the level three are colorful and dynamics.

Fig. 6. Monocromatic icons for the settings menu.

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