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The communication within heavy machine operator assistant system (HMOAS)

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Abstract

The scope and structure of communication between a heavy machine's operator and the computerised system HMOAS (in polish WORM) implemented to a backhoe excavator are presented. The system user interface employed enables a selected choice of information to pass on to the operator. The interface concept is based on a windowing system with hierarchical tree structured organisation.

1. GENERAL INFORMATION.

1.1. HMOAS system.

The main goals stated at the time of designing the HMOAS system can be divided into the following categories:

A. enlarging of attainable data connected with machine and its working activity, with simultaneous reduction of redundant data in any moment of working time. This category should be reached by means of replacing the traditional gauges in the excavator's cabin with an "intelligent" computer controlled console.

B. Heavy machine's diagnostics consisting of current state's observations based on measurement of selected parameters, signalling of periodical maintenance requirements, support of important checkpoint testing. Prediction of potential malfunction or emergency.

C. Collecting of data concerned with dynamic run parameters related to working process realised by machine; it is important to say, that in the first place this category has investigative premises, however it may refers to the advanced diagnostics tasks;

D. Automation of heavy machine by means of automatic and/or semi-automatic control having in view both easing operator of his work and obtaining optimum or quasi-optimum work parameters with reference to the selected.

Considering complexity of problems connected with automatic control, the system is realised in two versions, from which the first doesn't include control tasks, the second one is enlarged variant of the first version (with retaining of all its functions). The architecture and functions of HMOAS were described in [1].

1.2. The system's user interface.

The HMOAS is a computer system with heavy machine operator as its user. The whole of the user-system (program) communication is called user interface, being a subject of study and analysis both computer scientists and the other specialists like psychologists, human engineers etc., concerning with man-machine's communication problems (e.g.[2],[3],[4],[51).

Interface characteristics are set by its hardware and software features. The hardware features are connected with forms of user-system mutual interactions understanding as type of impulses having in view engendering of desirable reaction.

System's information is transferred usually by way of vision, supported more and more by sound (including voice communication). The user sends data and commands to the system by means of a mechanical impulse (keyboard, joystick, tablet etc.).

The program features are formed on this basis with the following factors taken into account:

(1) characteristics of user's knowledge, his experience and habits;
(2) user's tasks and his expectations and necessities connected with them;
(3) kind of information represented in system.

Industrial systems are equipped with various interface devices, among others in specialised units, adapted accordingly to specificity of transmitted data Gust as in all of monitoring and control systems).

In the case of stationary systems spatial constrains are not usually critical allowing for free formation of operator's activity space.

The matter contrasts that of mobile systems where spatial constrains, as well as features of operator's work, cause the necessity of data stream intensity reduction (filtration) or necessity of interchangeable passing on data by the help of the same device (or at most a few only).

Therefore it appears that the most flexible output device is a monitor display, principally a graphic one. It provides a programmed filtration of data as well as considerable freedom in output form's shaping. Moreover the window-oriented system is more generally accepted. In this instance, the window is a virtual object, qualifying possibilities of user's viewing into the system work. In numerous cases the whole display becomes the viewing window.

Taking into account analysis described in [6] one can recognise the basic features of a visual (graphic) monitor, i.e.:

i. transparency, which means quantity and legibility of attainable data;
ii. angle of view;
iii. resolution;
iv. contrast;
v. filtration and selectivity, connecting data representation with user's perceptive abilities;
vi. permeability, defining user's abilities of influence on system action interface with good permeability allows user for interference in every system action, particularly for interrupt of that;
vii. controllability, meant as ability of determining system action adjusted to user's power;
viii. delay of system response.

2. HARDWARE SOLUTION OF HMOAS INTERFACE.

The experimental-investigative system is much more complex than an application system and consequently the system cassette would be of a considerable size making it impractical to build into the cab's console. For that reason it appears logical to move the interface devices away from the system's cassette.

A very small amount of space is available to the designer, financial and technological restrictions also apply to the building of specialised interface devices, finally, must provide the possibility of carrying out experiments on the operator scope of perception with the small monitor display as the only accepted output device.

Current monitor displays are built accordingly with different technologies (CTRD, ELD, PD, LCD). Large differences in lighting levels exist within the machine's cab. A stable operator's position, neglecting the need for wide angle view, and low power consumption criteria led to selection of high contrast STN LCD display with backlight (cold cathode tube).

For decision information and data input it is necessary to use push buttons or keyboard/j oystick type actuators for control. The positive alternative is touch-screen display which allows joining together of a button's function with information about its use. Considering presence of different impurities an employment of infrared sensitive or electrostatic devices was given up.

A Japanese programmable terminal OMRON NT20 was chosen as a prominent part of the proposed interface. This terminal is equipped with a monochromatic, liquid crystal display with touch screen [7]. The main features of this terminal are as follows:

- High contrast;
- Small dimensions;
- Low power consumption;
- Able to pre-program screen contents as well as determine graphic characters.

Its only shortcoming is its small range of permissible working temperature (0 - 45°C), although the same range of temperatures also apply to the standard hydraulic control systems made by REXROTH (ref. 18]).
Additionally, the j oystick triggers are provided as input devices.

3. THE OPERATOR-SYSTEM COMMUNICATION STRUCTURE

For accomplishing tasks described previously in 1.1.1., processed data from measuring circuits were divided into categories Fig.1, as a base for selection when passing on to the operator. Information belonging to particular categories doesn't form separable sets, i.e. there is information belonging simultaneously to more than one category.

The operator is able to interact actively with system with a choice of system functions (option), in result that, for instance, windows representing proper information subsets are selected. Schematic diagram of possible operator-system interactions is shown in Fig.2

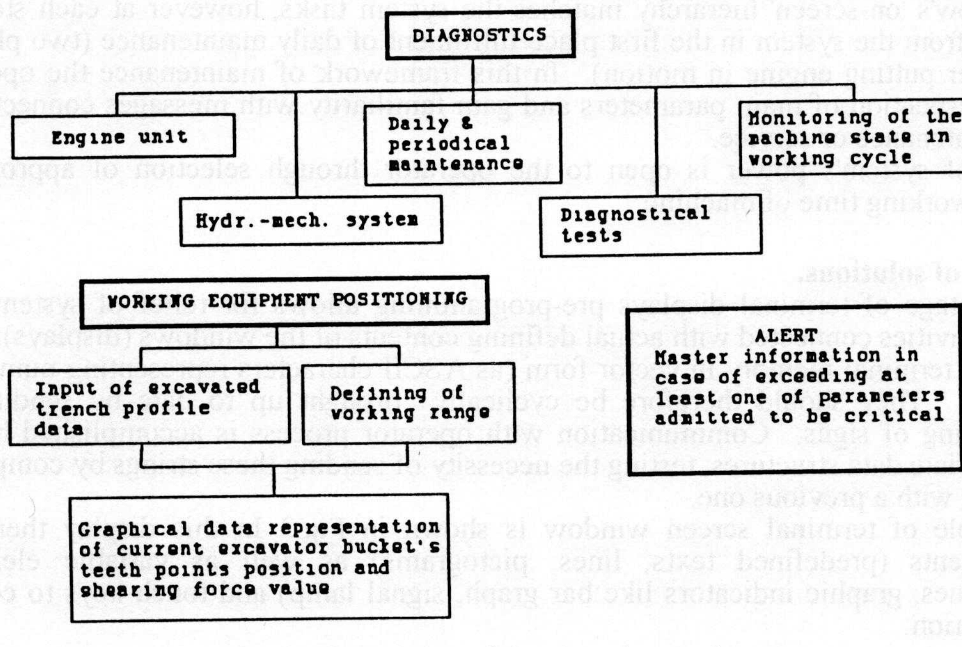

Fig 1 : Categories of data passing to the operator

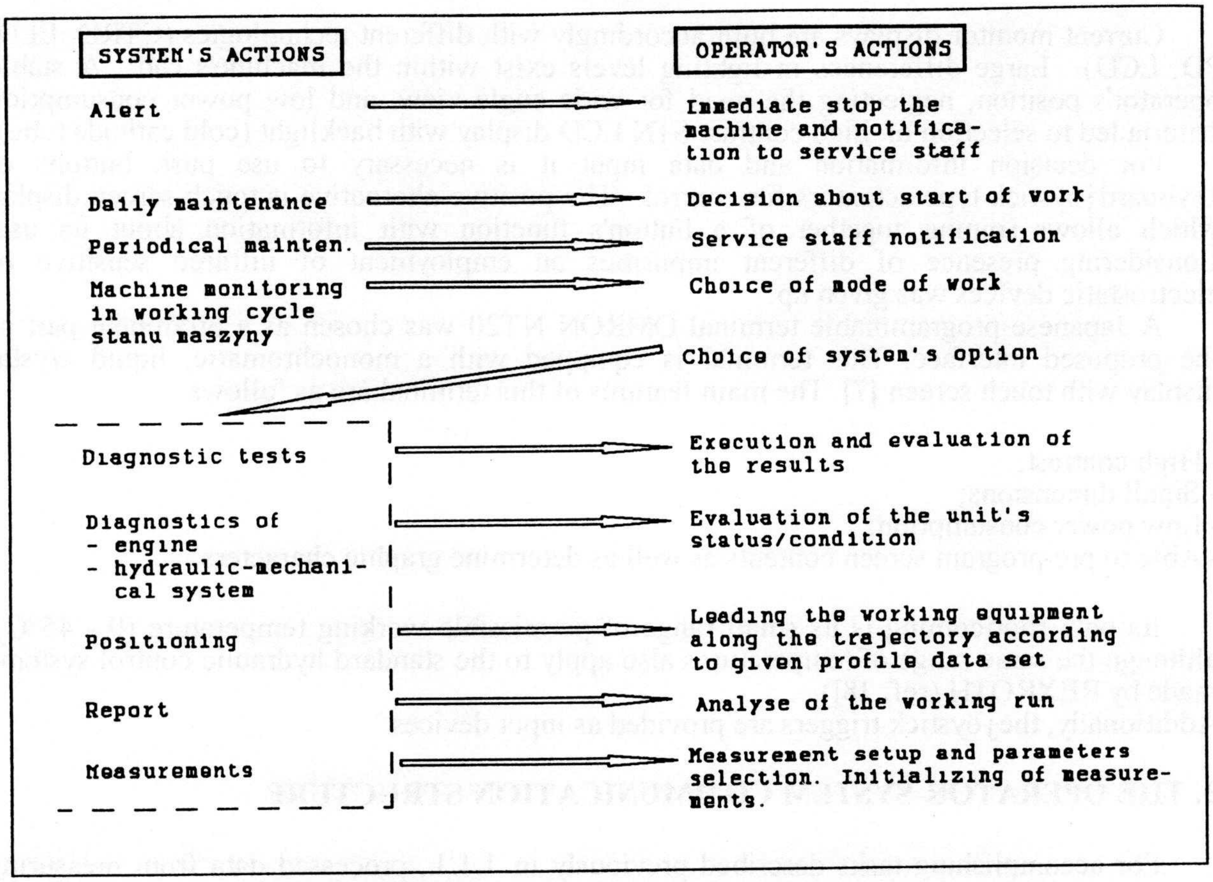

Fig. 2 : The operator-system interactions

4. SOFTWARE STRUCTURE AND SOLUTION.

4.1. Hierarchical structure of interface.

The window's 'on-screen' hierarchy matches the system tasks, however at each start an engine extorts from the system in the first place fulfilment of daily maintenance (two phases: before and after putting engine in motion). In this framework of maintenance the operator may execute inspection of main parameters and gain familiarity with messages connected to periodical maintenance or service.

The rest of system's power is open to the operator through selection of appropriate options in the working time of machine.

4.2. Examples of solutions.

The advantage of terminal displays pre-programming allows for relief of system processor from activities connected with actual defining contents of the windows (displays). Data is stored in the terminal memory in vector form (as ASCII characters representing numerical and text data). They should therefore be cyclically brought up to date by sending an appropriate string of signs. Communication with operator process is accomplished by the help of appropriate data structures, testing the necessity of sending these strings by comparing an actual value with a previous one.

An example of terminal screen window is shown in Fig.3 In this display there are constant elements (predefined texts, lines, pictograms) as well as variable elements (numerical values, graphic indicators like bar graph, signal lamp) and touch keys to control program execution.

Control decisions may be taken based on the option's selection, then display contains a set of touch keys. Numerical values are connected, for example the excavated trench profile, may be implemented through these keys as well.

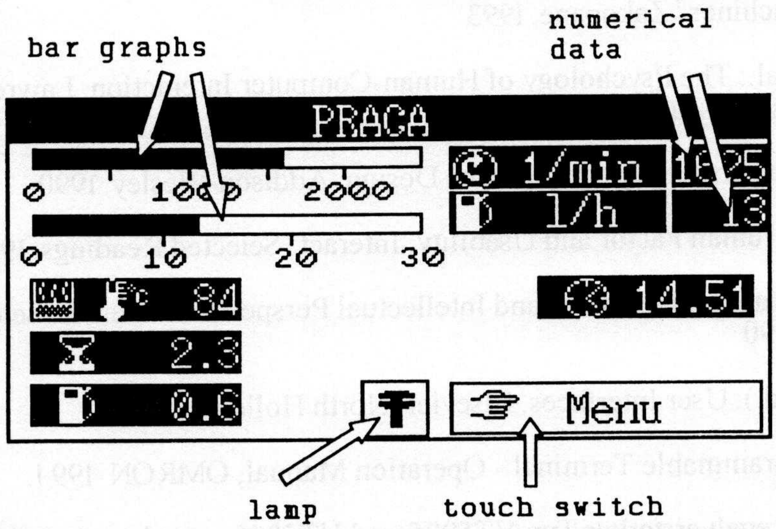

Fig. 3 : Screen example and its elements

CONCLUSION

The heavy machine-operator assistance system (HMOAS) was conceived as an experimental- investigative system. The conclusions of its structure and exploitation should be used for the construction of an applied system implemented in various versions on the board of serial produced heavy machines.

The presented form of operator-system communication, through selection and filtration of data, allows for supervision of many machine parameters without the necessity to observe numerous gauges and signalling lamps.

The next step towards improvement of operator's working conditions, and consequently quality and efficiency of machine work, is the implementation of an 'in-cab' dedicated operator's console with utilisation of all of the above remarks.

In highly automated heavy machines (such as an excavator), the role of the operator-system communication should be significantly increased at the expense of traditional dedicated direct control of individual working processes.

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