Investigation on User Experience Goals for Joystick Interface Design

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ABSTRACT

The automation of the crane operation system and the vehicle itself affects its control and handling operation, i.e. remote operation. Lack of direct motion feeling due to loss of physical interaction and experience between the operator and the crane has been recognized as a possible weakness in remote-operated container crane application. In order to improve this situation, this study aims to establish some insights on how to improve the lack of direct motion feeling through the joystick interface by means of interviews and observations with crane operators to establish user experience (UX) goals, as well as cognitive task analysis (CTA), need analysis and interpretation approaches. A total of 13 crane operators participated in this research. Based on their responses, eight positive experiences and eight negative experiences, along with several suggestions for lack of direct motion feeling improvement, have been identified and discussed. The results from this study provide a realistic feedback from the operators as end users in improving the control and handling interface for

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the remote operated container crane applications, which can also be extended to the general off-road vehicle industry.

Keywords: *User experience, end-users, engineering design, container crane, remote operation*

Introduction

The evolution of automation in off-road vehicle system like in the container crane application is influencing human-machine interaction elements as well as safety considerations among the operators. To date, several researchers have conducted their investigations to improve the vehicle performance and safety issues regarding remote-operated container crane [1–9]. Nonetheless, after several years of automation in the container crane system, one of the identified possible weaknesses in remote-operated container crane is the lack of direct motion feeling to the operator due to loss of physical interaction and experience between the operator and the crane. In addition, the operator has to depend only on the limited monitor views that are attached to the remote-operated station (ROS) to control and handle the cranes. This lack of direct motion feeling and limited operation view could lead to a less safe handling operation [4] and endanger other people in the terminal blocks.

This research study presents an investigation to obtain user feedback from crane operators to establish the user experience (UX) goals. It intends to establish some insights on how to improve the lack of direct motion feeling through the joystick interface. The results from this investigation will provide a realistic feedback from the operators as end users in developing a better design for the container crane applications, which can also be extended to the general off-road vehicle industry.

Theory

User Experience (UX)

User experience (UX) design is the process of enhancing user satisfaction of a product by improving the usability, accessibility and pleasure provided in the interaction process with it [10]. UX design encompasses the traditional human-computer interaction (HCI) design and extends it by addressing all aspects of a product or services perceived by potential users [11, 12]. Several studies have highlighted the different components of UX design. They are not necessarily contradictory to each other and explore the various aspects and perspectives in this very complex design concept. For example, three areas of UX have been delineated to go beyond usability in the holistic view that aims for a balance between task-oriented and non-task oriented components, whereas usability in subjective view is emphasized on the objective measures of their components such as percentage of tasks achieved for effectiveness and task completion times, as well as error rates for efficiency [13].

The new ISO Draft International Standard 9241-210 (2008c) defines UX as a person's perception and responses that result from the user or the anticipated use of a product, system or services. It has been suggested that the definition of usability can be extended to encompass the user experience by interpreting satisfaction, including liability, pleasure, comfort and trust [14]. UX is still a concept that is being debated, defined and explored by many researchers and practitioners [15]. However, it is clear that some components of this design concept has already been taken as an important element of the evaluation process in control, handling and automation system for industrial crane and their importance will further increase in the future.

Cognitive Task Analysis (CTA)

Cognitive task analysis (CTA) methods are focused on describing and also representing the vital cognitive elements that underline the goal generation, decision making, judgements, etc. Although CTA often begins with high-level description of the task based on initial interviews and observations, the raw data collection appears via in-depth interviews with the subject matter experts. These interviews emphasize on the focus to gain the information to develop cognitive strategies to accomplish the task, which include situation assessment, identification and interpretation of critical cues, meta-cognitive strategies and important perceptual distinctions. The primary strength of the methods is that they facilitate experts in articulating knowledge that is generally difficult to verbalize. Although researchers are regularly cautioned regarding the reliance on verbal protocol data [16], it could also be nevertheless argued that the verbal report is inherently no more or less problematic than any other methodology [17, 18].

The urgency of incorporating cognitive elements of performance in training and system design architecture from the inconsistent nature of the workplace may influence great impact of the technology on many underlining tasks and functions. Many of the current tasks require high-demands on the cognitive skills of human workers [19, 20]. It has been argued that the rapid growth in the advancement of technology and machine responsibility would increase the level of cognitive demands on human operators [19, 21]. There will be more procedural and predictable tasks that will be foreclosed by smart machines and devices. In the meantime, most human workers will be liable for specific tasks that will require inference, diagnosis, judgement and decision making. For instance, with the recent manufacturing technologies nowadays, human workers are required to have a few key skills such as perpetual skills for monitoring the equipment, diagnostic skills for interpreting computerized information and communication skills for problem solving and coordination of distributed decision environments. These are essentially grounded hands-on experiences with tasks requirement that requires proficient performers to access or articulate. Overall, technology often offers the potential to simplify low-level jobs. However, the major concern shared by many practitioners is that these scenarios make high-level tasks even more complex. It is clear that cognitive task analysis needs to be evaluated to develop an improved system design architecture for better human performance.

Engineering Design (ED)

In these recent years, ED has been continually applied and defined according to the complexity of a product in the development process. During the design phase, it is compulsory to obtain the engineering parametric to enable early product design specification establishment [22]. In line with this notion, the principles, methods and approaches in engineering design are emphasized in this research to analyse the UX results into better understandable criteria and parameters according to engineering definitions.

Methodology

13 crane operators from two international terminals had participated in this research, ranging in age from 25 to 31 years old. Six operators had two to three years of experiences in conducting Automated Stacking Crane (ASC) remotely while the other seven operators have one to seven years of manual operation experiences, and three months experience in remote Automated Rubber Tyred Gantry (A-RTG) operation during this research was conducted.

Before initiating the research study, a brief explanation was given to the participants about the purpose of the research, as well as the instructions and requirements of tasks to be undertaken during the study. Individual interviews and observations were conducted according to the outline in Ref. [23], in which every session consumed about an hour each. The interview sessions involved techniques such as semi-structured theme interview [25] and think aloud (TA) approach [26]. After that, all operators in every work shift were instructed to conduct the normal and daily operation routine using remote operated station (ROS) while a video recorded their activities for one hour. Cognitive Task Analysis (CTA), needs analysis and interpretation of end-users feedback from interviews and also observations was conducted to establish the UX goals to improve the lack of direct motion feeling through the joystick interface design [14, 24].

Results and Discussion

For this research purpose, it is assumed that the frequency of answers which ranges from 4 to 13 answers are considered as highly significant and they are listed in the top hierarchy of importance for future analysis to improve the lack of direct motion feeling through the joystick interface design.

End-users' Positive Experiences

Figure 1 shows the obtained responses for positive experiences from the 13 participating ROS operators. As can be observed, the top three answers with the highest frequency are: acceptable level of safety risk, good ergonomic of ROS and also low mental workload compared to manual handling. All of these answers have a frequency of more than four and this condition makes them highly significant in the context of this study.

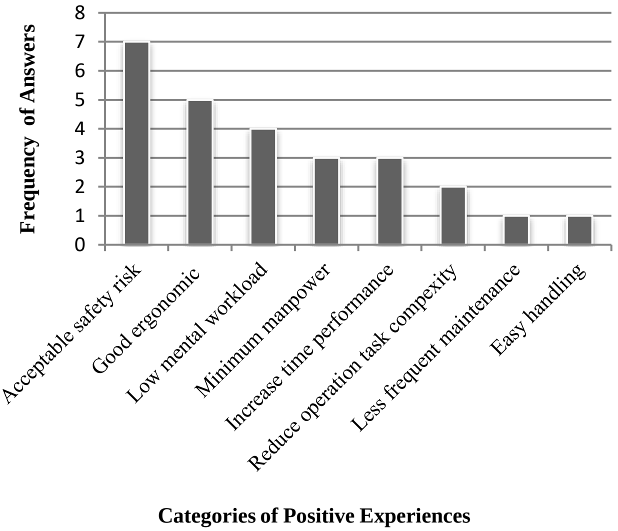

Figure 1: End-users' positive experiences in using the existing ROS

End-users' Negative Experiences

On the other hand, Figure 2 highlights the answers given by the participating ROS operators with regards to their negative experiences in using the current existing ROS. As can be seen from Figure 2, the highly significant answers with a frequency of four or more are those within the top five answers. They are: time delay issue, problem detection, lack of communication options (in particular, during unexpected crisis situations such as monitor malfunction), visual limitation and last but not least, problem in handling smoothness.

End-users' Suggestions

The research participants are also enquired to pick on several suggestions to improve the lack of direct motion feeling through the joystick interface. Their answers are presented in Figure 3. Based on the frequency of the answers, the two highly significant suggestions are improvement of the communication options and the joystick ergonomics.

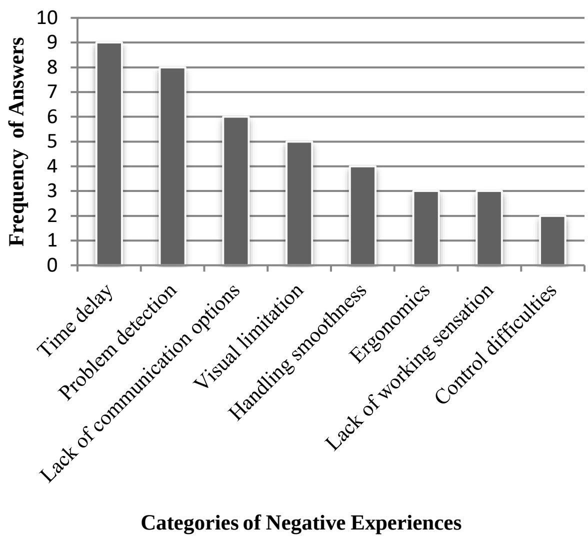

Figure 2: End-users' negative experiences in using the existing ROS

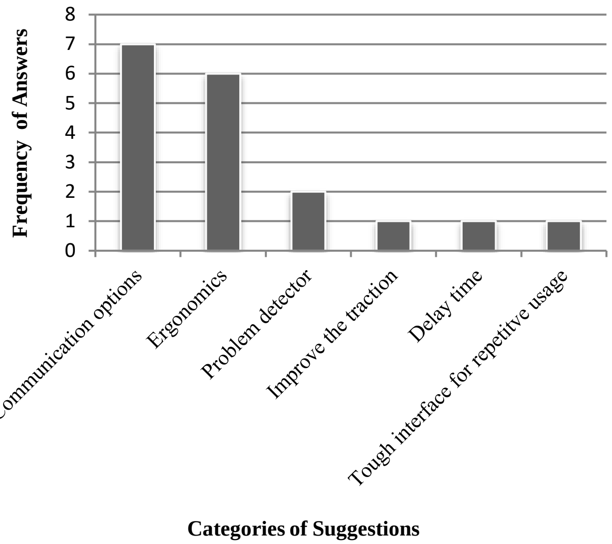

Figure 3: End-users' suggestions based on their experiences

UX Goals

Based on the UX results shown in the previous Figure 1, the current existing ROS seems to provide an acceptable level of safety risk to remote operators, has generally good ergonomics and the operators commonly experience low mental workload during their control and handling activities. Therefore, these three positive experience categories should be excluded from being the UX goals of this research. On the other hand, the other categories that have been rated low are investigated further to be associated with the results of negative experiences.

Meanwhile, the results in Figure 2 have confirmed the lack of direct motion feeling that occurs during the control and handling operation due to several factors such as time delay, problem to detect the error in ROS system, lack of communication options between the operators, interface and people in working terminal, visual limitation such as limited monitor size and problem in handling smoothness due to force and traction. These five categories will be accounted as main UX goals and they will be evaluated further in the next analysis. Furthermore, the presented results in Figure 3 can be considered as a support for obtaining responses regarding negative experiences, especially in finding suitable ways to resolve them.

Table 1 summarizes the findings from this study by tabulating the main UX goals that are derived from the obtained results of the investigation.

These goals have been formulated for the objective of overcoming the lack of direct motion feeling through the joystick interface, particularly in remote container crane applications.

Table 1: Main UX goals of the results analysis

No.	UX Goals
1	Time delay
2	Problem detection
3	Lack of communication options
4	Visual limitation
5	Handling smoothness
6	Ergonomics

Conclusion

All in all, measures of eight positive experiences, eight negative experiences and also six suggestions are obtained from 13 participating ROS operators to improve the lack of direct motion feeling issue through joystick interface design. These are obtained through interview sessions with the operators and also observed while they are performing their tasks. Based on the results, six main UX goals have been established for consideration in the joystick interface design. The next following step in this research is to compare and contrast the established UX goals with the ones from previous studies. This is an essential step to verify and define the scope of UX goals for future works in this research study. Once these UX goals have been solidified, the focus of the research will be directed to the establishment of user experience parameters and engineering parameters based on the goals, in order for them to be measured and physically tested.

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