A PROPOSAL FOR INSTALLATION ARCHITECTURE FOR VIDEO CAMERAS AND SCREENS IN AN INTEGRATED VISION SYSTEM FOR CRANE CABINS

Abstract: The increased industrial activity involving cranes as well as the growing complexity of crane operations have increased the risks of safety of the personnel involved and the goods being handled in such tasks, as well as productivity, quality and utility of crane based services. As a consequence, there is a growing demand for technologically and functionally more efficient design as well as solutions. The presented paper proposes installation architecture to address such demand, for video cameras and screens installation in an integrated vision system for cranes. The proposed integrated vision system aims to provide the crane operator, sitting inside the crane cabin, different views through the cameras mounted around the crane and for the object being handled by the crane. This solution aims to provide a new generation of crane systems with safer work environment, productivity, quality and utility of crane systems.

Keywords: Crane, Crane Cabins, Integrated Vision Systems, Video Systems, System, Work Environment Safety

1. INTRODUCTION

With the increment in industrial activities involving cranes, and the overall complexity of operations in such activities, there has been a growing demand for more efficient processes as well as equipment for such operations. These operations involve “heavy-weight” machinery and this fact also implies safety issues of the operators as well as high probability of damage to the goods being handled. To address these challenges one approach is to have better design and functionality solutions of the equipment as well as the operations. The presented paper proposes an integrated vision system inside the crane cabins as one such solution.

As a result of the complicated and constantly changing nature of industrial and construction work, there are very high injury and fatality rates, where cranes contribute to as many as one-third of all fatalities and injuries resulting in permanent disability [1]. The Crane and Hoist Safety report prepared by OSHA reported a death rate of 1.4 deaths per 1000 operators [2]. There are more such reports confirming similar trends [3, 4]. Human error is the cause of almost 60% of lifting operation related accidents [1], which is not surprising since crane operators still work in ergonomically unadjusted surrounding with very high visual tension in stressful working conditions due to both physical stress (shocks, vibrations and accelerations which are transferred to the operator directly or indirectly by the oscillating supporting structure and due to the oscillation frequencies of the cabin structures themselves), and psychological stress (the sway of the load, extremely low visibility of cranes, etc.). Additionally, the ever growing competitiveness in the international and/or national market makes further improvement in the management, effectiveness and efficiency of crane operations and crane systems absolutely essential. According to previous research results [1, 2, 5, 6], a new solution for crane cabins is needed and it is CABIVS’ aim to develop a new generation of crane cabins which are able to solve the aforementioned problems. The goal is to develop crane cabins as ergonomically adjusted, light weight and integrated visual systems for the detection and interpretation of environment based on the translation of user needs into functional requirements.

This paper proposes architecture for
installation of video cameras and screens in an integrated vision system for crane cabins. The positions of the video cameras as well as the user interface are given, considering the safety and efficiency of the crane operator sitting in the crane cabin.

2. VIDEO CAMERAS INSTALLATION ARCHITECTURE

Considering the above mentioned safety as well as efficiency issues, a new crane cabin setup is proposed within the CABIVS project. The proposed crane cabin setup includes an integrated vision system. The integrated vision system consists of several video cameras and a custom built software tool with user interface to display live video feeds from these cameras. These video cameras are positioned at different points on the crane structure, to give real-time views of the position of crane, and positions of its different parts as well as elements in its surrounding environment, to the crane operator who is also the user of the software tool of the integrated vision system.

A graphical representation of a crane structure equipped with the proposed integrated vision system is shown in Figure 1.

In general, there are 7 positions identified on different parts of the crane to install video cameras. These are numbered in the Figure 1. These positions are decided considering various “view zones” that the crane operator should be looking at on any given moment during the crane operation. Additional cameras could also be installed on other points on and outside the crane as required. As an example, an eighth video camera could be positioned at a safe distance from the crane and the video stream from this camera is to give the view of the whole crane from a distance. Figure 1 is indeed a possible view from the eighth camera.

All the video cameras are so called P/T/Z cameras (7), i.e. they allow the user controls of panning, tilting and zooming in order to adjust the view.

![Figure 1 - Video Cameras Installation Framework for Integrated Vision System for Crane Cabins](image)

Views from each video camera are described below -

Camera 1 – this video camera is installed on a mechanised chain attached with the crane structure also with a small conveyer wheel structure. This structure can move in parallel with the hook, also controlled by the crane operator, to keep a constant view of the object being handled by the crane. The purpose of this camera is to give the view of the object from the opposite side to the crane operator. See Figure 2(a).

Camera 2 – this camera is mounted on top of the hook, and shows how the hook carries the object, i.e., if the object is hooked and positioned properly. The camera is hanging like the camera 1, and its vertical position can also be adjusted according to the position of the box that carries hook. See Figure 2(b).

Camera 3 – it gives the backside view
(rear view) of the crane structure to the crane operator. As the crane cabin moves, the operator sitting inside the cabin has proper view of the front side, but is completely unaware of whatever is in the back side – a view that is provided by this video camera. This is to give a complete 360° view of the surrounding environment to the crane operator sitting inside the cabin. See Figure 2(c).

Figure 2 - Views from Video cameras Installed on the Crane Structure
Camera 4 – this camera is mounted on the top most point of the crane structure cabin. It gives a bird’s eye view of the crane structure and its immediate surroundings.

Camera 5 – mounted at the bottom of the crane, this camera provides the most important view from the point of view of safety of the object being handled as well as the personnel working nearby the object. The tilting movement of this camera is useful for verification of anything that can be on any side of the object while the object is being lowered. See Figure 2(d).

Cameras 6 & 7 – attached on either sides of the hook box, these cameras give the left and right side views of the object from the above. This configuration is particularly helpful in case the object being carried is a big wide container. See Figures 2(e) & 2(f).

The live feeds from these video cameras are provided to the crane cabin operator through the integrated vision system. The proposed system does not apply any automatic object recognition functionality as in other integrated vision systems [8, 9], but instead provides real-time information in the form of live images to the crane operator enabling the operator to carry out cognitive decision making process to avoid accidents and execute the task more efficiently and rapidly, minimising the error. The system is to assist the crane operator rather than substitute the crane operator through automation. A more appropriate description of the objectives of the system can be found here [10].

3. VIDEO-DATA FLOW SYSTEM OUTLINE

The system outline in Figure 3 briefly shows the overall architecture of the proposed system. The video cameras are connected to a video streaming device, which is basically a computer where the software of the integrated vision system is installed, that processes the videos captured by the cameras. On the frontend, there is graphical user interface (GUI) of the software application to display videos. The streaming device outputs the videos to the GUI which is seen by the crane operator (user).

![Figure 3 - Video-Data Flow System Outline](image)

The flow of the data in this system is only one sided, from cameras to the user interface, via the streaming device. The camera controls for pan-tilt-zoom are provided through direct hardware connections for each camera.

4. USER INTERFACE FOR CABIN OPERATOR

The graphical user interface of the integrated vision system has different windows each showing live images from the selected video camera. The user may select a video camera to see its video feed in a particular window. Figures 4(a) and 4(b) show different camera feeds selected by the user. Figure 4(a) has “Cam1” selected from the buttons on the left panel, and Figure 4(b) has “Cam2” selected. Also, the windows are resizeable with digital zooming enabled. This zooming is in addition to the optical zooming provided in the
pan-tilt-zoom hardware controls.

The Figure 4 shows two examples of video feed selection by the user (crane operator). It is seen that the interface allows the crane operator to have a real-time view of the whole crane structure from different angles.

A green indicator on the lower right corner of the central window shows the live video feed is functioning correctly and is currently “ON”.

![Graphical User Interface of the Integrated Vision System](image)

**Figure 4 - Graphical User Interface of the Integrated Vision System**

5. CRANE CABIN SETUPS WITH INTEGRATED VISION SYSTEM

Two different models of setup of the video screens inside the crane cabin are proposed with the installation of integrated vision system.

![Setup Models for Video Screens with Graphical User Interface inside the Crane Cabins](image)

**Figure 5 - Setup Models for Video Screens with Graphical User Interface inside the Crane Cabins**
5.1 Single screen video interface

In this setup model, a single monitor is installed in the crane cabin. See Figure 5(a). This single screen displays multiple video feeds from different cameras as selected by the crane user. See Figure 6.

5.2 Multiple screens video interface

In this setup model, 3 monitors are installed in the crane cabin. See Figure 5(b). The multiple screens, each displaying one or more live video camera feeds, enable the user to get the complete view of the crane’s different parts and its immediate surroundings that can be affected by the crane operations, or that can affect the crane’s operations. Again, the user can select which screen and which window of the screen displays which video feed. The added screens allow the crane operator to see all the video feeds simultaneously without need to reduce the sizes of the videos beyond a limit. Thus the crane operator does not miss any view and also gets all the views reasonably clearly.

Further, it is possible to use the graphical interface of the software application in more productive and effective ways, while employing multiple screens setup model. For example, the middle screen may show several video feeds from different angles, with one of them selected in bigger size, and the two side screens may be configured to show only the two sides of the object being handled by the crane’s hook. See Figure 7(b).
6. CONCLUSIONS

This installation framework permits a number of configurations in the sense that the solutions could be personalised for different purposes and operational requirements. At the moment, the prototype software is developed and tested. Future work will address development of:

- more user friendly interfaces;
- installation architectures for remote control of crane operation;
- integrated vision system for multiple crane systems;
- embedded intelligent video systems; as well as
- testing of these systems.

REFERENCES: