International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-2 Issue-5, November 2013

Current Status and Key Issues of Automated Robotic Crane for Various Industrial Applications

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***Abstract**—Increasing the trends of productivity in industry, which consumes less space, less time are going on day to day. Technologically sound device need to be used to cope up with the situation. This Robotic Crane will be employed in the transport industry for the loading and unloading of freight, in the construction industry for the movement of materials and in the manufacturing industry for the assembling of heavy equipment. This research is motivated by the increasing usage of cranes, cost and safety issues in construction erection, manufacturing processes and the difficulties of planning in projects involving multiple cranes. Robotic crane even suits the applications such as welding operation, spray coating, assembly, inspection etc. Robotic crane which is provided a camera and remote can even work in hazardous conditions such as 'bomb detection', mines etc. It gives accurate and efficient work in small space and consume less time. It can also be modified for further applications. This initial effort integrates and extends prior research in robotic crane employment, loading and unloading of goods and camera enabled component tracking and visualization.*

***Keywords**—4D model, RF signal processing, Robotic Arm and Wireless Vehicle.*

I. INTRODUCTION

In order for a project plan to be reliable, it needs to follow a certain control mechanism to ensure that the project goals can be achieved. As a result, using lessons learned and information collected from previously completed projects only can help project planners to a certain extent. In fact, the best approach to manage a new project is to design and incorporate a customized planning and control strategy unique to that project. Such strategy should facilitate the integration of the project information into project schedules not only during the planning stage but as the project makes progress. The aim of this research is to develop knowledge and tools required to implement automated robotic crane processes. Although we do not envision an operator-less robotic crane implemented in the near future, we do envision robotic cranes that assist crane operators for erecting structures in a safe and time optimized way. This research provides fundamental knowledge and tools that will enable in the long term to have autonomous Robotic cranes that "know" where to pick up and place elements in a fully optimized sequence transport them in safe and time-optimized paths and interact efficiently and safely with other cranes on the job. Robotic cranes linked to computers, 4D models (3D geometry model plus time) and sensors would then provide a faster, more economical and safer erection.

Revised Manuscript Received on 30 November 2013.
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II. PREVIOUS STUDY

The ongoing research builds on and expands on research conducted previously by several investigators. Previous research can be categorized by two coordinates, the degree of automation and the degree of reality .The degree of automation can be sub-categorized into three levels, which are manual, integrated (partially manual and partially automatic), and fully automatic. For example, the construction cranes used in most of the jobsites belongs to the manual level because they need to be controlled by operators for each motion to complete a given task. In terms of the degree of reality, the research can be separated into three groups: abstract models, virtual reality, and the real world. For example, conventional 2D CAD models used in current construction practice can be considered as abstract models. Since 2D models are presented only on two dimensional medial, such as papers or computer screens, they have inherent shortcomings in terms of their ability to represent dynamic objects and information from the world. Therefore, engineers use abstract symbols special drawing methods to enrich the 2D models to convey more information. However, these abstract methods impede people who do not understand the meaning of the models and sometimes even cause communication difficulties between different expertise. 4D models and animation models present the processes in a virtual environment generated by computer graphics.

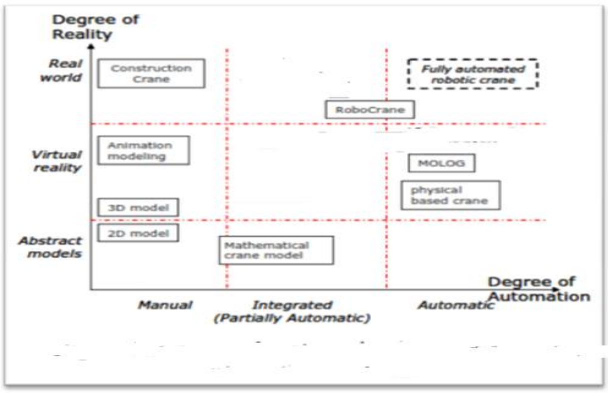

Figure 1. The Research Categorized By the Degree Of Automation And Reality

VITASCOPE[1] developed more detailed and operational-leveled animation to simulate construction processes in detail. These virtual reality models can significantly improve the quality of communication between the project members of different backgrounds.

The 4D [2] model is developed in a virtual world, but eventually will link to a robotic crane to provide a faster, more economical and safer erection. Motion planning [3] is a key element for providing manual cranes automated capabilities. The main goal of motion planning methods is to find continuous collision-free paths by giving a robot initial and target positions. With some modifications, it is an ideal tool to be applied in cranes as an automated planner. Some recent research has applied motion planning to crane usage. The MOtion for LOGics[4] (MOLOG) project developed motion planning tools inside the usual CAD system, which facilitated the complex and trivial crane operation for the maintenances of a nuclear power plant. Siva Kumar [5] used a motion planning algorithm to assist a cooperative lifting plan. Although this research only focused on some specific problems in construction, it demonstrated the potential of motion planning algorithms. Once a reliable motion planning algorithm for a crane is developed, an automatic scheduling system can be developed. Future engineers may use the computer software to schedule the project with both geometrical reasoning and time accuracy. Some previous research has focused on visualizing the crane operations. Lipman and Reed [6] have developed 3D crane models in a virtual environment. The crane model developed from the research can be "manipulated" to complete some construction tasks in a virtual environment. Chui [7] demonstrated the process of operating a tower crane to install curtain walls in a virtual world.

III. PROBLEM DESCRIPTION

- As far as the material distribution is concerned, the crane is the most important means of transport which implies that delays in crane operations can potentially cause bottlenecks in project schedule.
- Conventional cranes take more time and hence its usage gets limited.
- Even these cranes can't work at high temperature and hazardous working conditions. It can cause endanger to human property and also huge losses in crane's components.
- If crane is fully automated there is endanger of reduction of employment.
- Conventional cranes cannot perform auxiliary operations such as welding, painting, assembly of machine parts.

IV. PROPOSED SYSTEM

Conventional cranes take more time and hence its usage gets limited. Even these cranes can't work at high temperature and hazardous working conditions. Hence advancement i.e. providing crane with remote sensing device and a camera which can work in hazardous conditions will be employed. Camera will allow driving these cranes where it can cause danger to human property. Remote sensing makes it possible to collect data on dangerous or inaccessible areas. Remote sensing also replaces slow data collection on the ground, ensuring in the process that areas or objects are not disturbed. The difficulty faced is that cranes cannot hold things with varying shapes. So, it will be provided with multiple holding devices (end effectors) such as manipulating arm cutter or grabber arrangement or electromagnetic grippers. This allows cranes to hold materials with any shape. Also there will be no loss of employment as instead of driving, employee will now be used for controlling crane and its motion. The RF signal processing can be explained as follows, TRANSMITTER - A radio transmitter is an electronic circuit which transforms electric power from a battery or electrical mains into a radio frequency alternating current, which reverses direction millions to billions of times per second. The energy in such a rapidly-reversing current can radiate off a conductor (the antenna) as electromagnetic waves (radio waves). The transmitter also "piggybacks" information, such as an audio or video signal, onto the radio frequency current to be carried by the radio waves. When they strike the antenna of a radio receiver, the waves excite similar (but less powerful) radio frequency currents in it. The radio receiver extracts the information from the received waves A practical radio transmitter usually consists of these parts:

- A power supply circuit to transform the input electrical power to the higher voltages needed to produce the required power output.
- An electronic oscillator circuit to generate the radio frequency signal. This usually generates a sine wave of constant amplitude often called the carrier wave, because it serves to "carry" the information through space. In most modern transmitters this is a crystal oscillator in which the frequency is precisely controlled by the vibrations of a quartz crystal.
- A modulator circuit to add the information to be transmitted to the carrier wave produced by the oscillator. This is done by varying some aspect of the carrier wave. The information is provided to the transmitter either in the form of an audio signal, which represents sound, a video signal, or for data in the form of a binary digital signal.
- In an AM (amplitude modulation) transmitter the amplitude (strength) of the carrier wave is varied in proportion to the modulation signal.
- In an FM (frequency modulation) transmitter the frequency of the carrier is varied by the modulation signal.
- In an FSK (frequency-shift keying) transmitter, which transmits digital data, the frequency of the carrier is shifted between two frequencies which represent the two binary digits, 0 and 1.

RECEIVER - A *radio receiver* receives its input from an antenna, uses electronic filters to separate a wanted radio signal from all other signals picked up by this antenna, amplifies it to a level suitable for further processing, and finally converts through demodulation and decoding the signal into a form usable for the consumer, such as sound, pictures, digital data, measurement values, navigational positions, etc. The receiver is "tuned" to respond preferentially to the desired signals, and reject undesired signals.

ANTENNA - An antenna is an electrical device which converts electric currents into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter applies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves).

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In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals, that is applied to a receiver to be amplified. An antenna can be used for both transmitting and receiving.

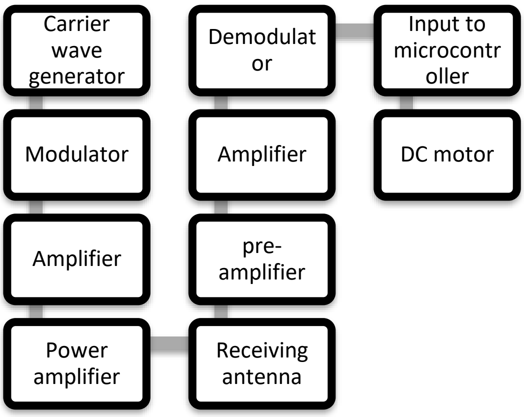

Figure 2. Block diagram of RF signal processing.

V. OTHER ROBOCRANE APPLICATIONS CONSIDERED

The RoboCrane is sufficiently stable for doing variety of tasks could aid workers toward advanced tool and equipment manipulation. The RoboCrane test beds have demonstrated:

- Welding and grinding using teach and off line programming control as the tool platform supports the weld torch
- Material and equipment handling using joystick, off line programming control with the gripper, quick change or other grabbing device
- Inspection of an object using a line scanning laser attached to the tool platform while the scanner maneuvered using joystick control

VI. RECENT RESULTS

Currently, we are able to achieve autonomous placement of LOAD using RoboCrane in the area defined. RoboCrane was able to autonomously place a load at a relatively slow speed hence, not yet suitable for other mentioned purposes. A brief description of the placement process follows.

Once the working volume is defined and calibrated, the hook and scope (end effector) picks up the load, moves along with the load to the required destination where it places the freight. Even ferrous material can be picked and placed using electromagnetic gripper. Dust or weather conditions were not hindering factors in the proposed scenario. In addition device was dust and water proofed.

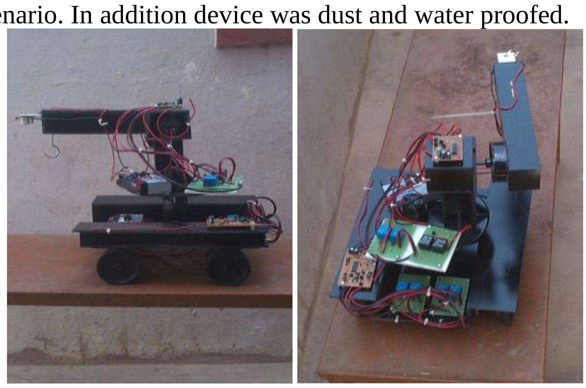

Figure 3. Front view and Top view of Robocrane

VII. CONCLUSIONS AND FUTURE WORK

The ultimate goal of any project is to meet both schedule and budget requirement. Uncertainties are of the greatest impediments to planning and decision making. Project schedule are useful tools for managing projects only if they represent the actual condition of project. The key to successful project is to have a clear strategy that spans over a lifetime of the project. Activities that rely on crane service usually fall on the project critical path and if mismanaged, can result in several project delays and cost over runs. In this paper, a data collection and methodology was presented which allowed planning and controlling of future crane activities based on the latest performance on the work site. We are also planning and working on significantly increasing the system's pick and place in our effort to meet or surpass current practices.

Although RoboCrane is currently developed only for conventional applications, we believe that much of this research will be useful and helpful for design-for manufacturing and fully automated robotic crane in the near future.

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