WORK FORCE CHARACTERISTIC IN A ROBOT DRIVEN CONSTRUCTION INDUSTRY

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Abstract: The gradual arrival of robotics onto the construction scene in the past two decades has given rise to a whole new realm of mechanization and management. In order to decline which tasks are best suited for automated construction, the different levels of automation must first be defined. Theses are mechanization, robots, mechanized construction systems, and fully automated construction. With an understanding of what constitutes "automation" the impact on construction site requirements can be addressed. Historical opposition in the United States resurfaces with the emerging robotics has an impact on their implementation for construction managers and other personnel. How and why robotics is used in construction will depend on human response and evaluation systems, and may ultimately decide the fate of any project. This paper will also introduce new strategies that blue-collar workers will have to develop in order to maintain produce of robots on the construction site. Finally, this paper will discuss what industrial changes can be made to encourage the integration of automation.

One of the most important factors in the implementation of robotics on the construction site is human response. From laborers to construction manager, automation has been welcomed with hesitation at best, hostility at worst (Singh, 1991). Despite the introduction of many well-publicized prototype robots, there have been very few examples of robots that can compete favorably with human workers. In the United States, the utility of automation and robotics to satisfy owners and managers demands has been weak. Part of the controversy over robots in construction, stems from the fear of loss of job security. Automation and robots perceived as a threat to job security and wages, despite the improvement in job conditions; because of this, workers' satisfaction is given a poor rating (Everet 1994). The introduction of robots in construction in the past two decades has created new roles for human laborers, while eliminating several traditional roles. The transition from manual working methods to mechanical methods, in foreign countries, was implemented differently in construction, thus the prerequisites for automation and the use of robots vary considerably (Cousineu 1998). As increasing numbers of robots are introduced in construction, the activities and skills required of human workers will change. For this reason many foreign countries, including the United States have chosen to use robots in very limited areas.

While human construction workers are still a necessity in the field, their numbers are dwindling. Most robots in use today are designed to assist humans, not replace them in situations where laborers are already lacking. This is especially true in jobs that are labeled as tedious, strenuous, and repetitive. To give the construction worker a better understanding of robotics, the robots will become a part of the construction team. This addition to the team is not an attempt to down size or lesson responsibilities on the job site. The strategy is to provide the blue-collar worker with a higher level of education. This higher education will give the blue-collar worker the ability to program and maintain the robots. During the past decade there has been a great need for manual labor in construction, and this addition will be one of the solutions to solve the labor shortage problem.

Robots in Construction

There is a multitude of ways to distinguished robots from on another. Each research and development division classifies their products in ways convenient to their individual strategies, but not necessarily to the construction industry as a whole. For the purpose of keeping the assessment of robotics simple, the levels defined by researchers At Taisei, a major contractor in Japan, will be used. Each category can be broken down into numerous sub-levels of automation: mechanization, robots, mechanized construction systems, and fully automated construction. The upper levels are more complex, less commonly used in the industry at this present time, and are built upon the technologies of the lower levels (Fujinami etal. 1995).

The lowest level of robotics and automation is the mechanization level. These tools are already commonly used on project sites, and often require the guidance of human laborer. Generally, devises that substitute mechanical power for human power fall into this category. This would include such items as a simple nail gun, a wallboard manipulator, and a floor-brushing machine. Each of these relies on the sense of a construction worker to manually dictate where the action is performed (Fujinami et al., 1995). The actions of mechanized devices generally lessen human strain, while still demanding a high level of skill on the part of the laborer.

The term robot refers to "an apparatus that can perform part of all of its task without direct human supervision or guidance." In this context, a robot is more complex than mechanized tools, in that a laser or other method of tracking is commonly used to guide its progress. Some robots may even possess artificial intelligence, though this is not a requirement for this classification. Humans generally need to input information into the apparatus, and still be responsible for guidance or placement. This may be done physically or through remote control. Additionally, supplies for the robots task may need to be loaded individually. Some robots may perform more than one task, or be designed to handle a variety of materials. Almost all successes in construction automation have been devices that perform one task and are controlled by a human operator who guides the machine and devices performance temporal and spatial boundaries (Everett & Slocum, 1994).

One example of a "robot" is the TRUST excavator, a machine used to build watertight, and very thin slurry walls. What makes this apparatus fall into this category is its positioning system. Sensors on the device collect data about the excavator's absolute position and inclination, and then the machine adjusts itself to remain on the correct course (Fujinami et al., 1995). Another example is the "Kote-King" concrete floor finishing robot by the Kajima Corporation, which travels along a path automatically using a microcomputer, gyrocompass and travel distance senor (Cousineau & Miura, 1998). According to recent study, almost all robots in use today fall into the category of material-handling robots or floor finishing robots (Warszawski & Navon,1998). Unfortunately, due to the numerous obstacles to robotization in construction, prototypes are abundant, but few practical examples can actually be found on construction sites today (Everrett & Slocum, 1994).

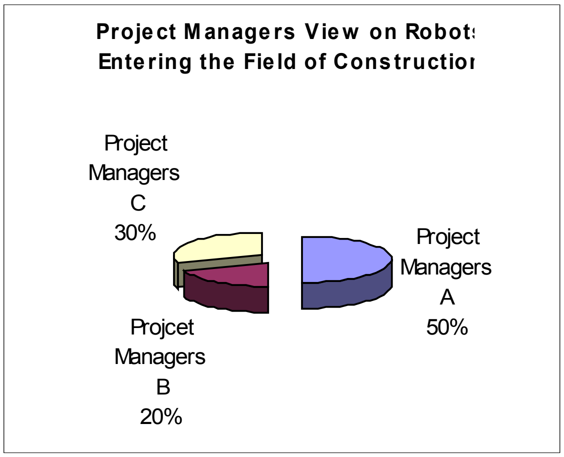
Mechanized construction systems are an organizational step above robots. Essentially, a system refers to a group of robots performing separate and distinct task, but integrated or sequenced to perform a larger activity. Human workers are still required to complete construction, but they are helped by a number of robots rather than one designated for a sole task (Fujinami et al., 1995). Research in this area is becoming more popular, but the fleets involved tend to be more costly, and require a good deal of maintenance. Fully automated construction is not really being used in the field on a researchable level. It is by far the least common form of automation, even among research and development divisions. The purpose of full automation is to completely remove the need for human laborers. The fully automated construction site would be arranged like a traveling manufacturing plant. It requires a higher level of consistency of surroundings. For this reason, most research is done involving construction that can be accomplished within a structural box. This would be useful in building with standard plans that are repetitious, such as a high-rise building (Fujinami et al., 1995)

Methodology

To better understand the relationship robots have with humans, a questionnaire was organized. The questionnaire targeted construction workers and the general public. The reason for using both experienced workers in the field of construction, and the general society, was to discover where the fear of robots actually started. The survey was designed to give rationalized answers, rather than straightforward answers. Many people "jumped on the band wagon" when it came down to expressing their ideas. The questionnaire was conducted at construction sites, construction offices, shopping malls and universities. When interviewing construction workers, it was important to receive opinions from every experience. The questionnaire was also given to the owners of the buildings being constructed. In the shopping malls and at the universities, people were chosen at random and asked several questions one on one.

Results of Survey

Out of 20 project managers interviewed, 50% of the project managers felt that robots would be a good asset to construction, 20% felt that robots will take away jobs and 30 % felt that robots will just get in the way. Figure 1 illustrates these statistics.



Sub-contractors and their managers felt that the addition of robots would add to construction time. They felt that robots would add more time to mobilization. In a traditional sense, they felt that many of the workers would not want to be educated to have to maintain the robots. Many of the other contractors did not mind robots being added to the team as long as the robots did not interfere with their work. People that were interviewed in shopping malls felt that robots were only good for down sizing. Students from the universities had mixed opinions, students from technical and engineering schools felt it was a wonderful idea, but the students from non-engineering schools felt it really did not matter.

Path to a Higher Education

The real issue is not operating the machine; it is being able to repair the machine if it fails. The machines are designed to be “dumb” machines. Dumb meaning basically anyone can operate the machine. How not knowing how to fix the machine once it breaks down can cause a delay in the project. Which is the need to emphasize the importance of the operator or supervisor to become highly educated mechanics, robotics and management. Building construction involves a variety of jobs, which run the gamut of the operation process of the installation of building exterior and interior materials. The process is so complicated that most requires human hands (Beavan & Collie). Accordingly many attempts to mechanize and robotize those operations have started so that operation efficiency would be improved. The drawbacks however are, robots are designed to perform monofunctional task (Beavan & Collie). To carry out each type of work at the site, individual work could be optimized in order. The number of types and the total number of robots that could be brought to the site would be excessively large, which would lead to great problems in preventing the comprehensive optimization of systematic operations and central cost.

Many robotic machines are designed with user-friendly operations. The major components of a semiautomatic navigation system is a programmable controller, three speed encoders, several limit switches, a wireless remote control set and a user friendly, Man Machine Interface (MMI) (Rosefeild 1992). Most robots are designed for very little training. To operate an automated crane, experienced crane operator needs merely a few hours of training in order to start working the automation option. The emphasis in training should be on safety aspects and efficient strategies instead of the basic operation. However, the idea that needs to be emphasized is upgrading the blue-collar worker’s ability to understand the basic operations and the technical support of the machine.

Construction workers are interested in job security, wages, safety, decent working conditions and the reduction of heavy lifting, dirt and dangerous repetitive work. To satisfy the demands of the workers, blue-collar workers will be given a new set of responsibilities in the field. The blue-collar worker will have to take specially designed courses that will strengthen their skills, knowledge and abilities in the area of robotics, mechanics and management. In order to bring this concept to realization, it requires the integration of a variety of complex systems at a very high technical level. This can only be successful if an interdisciplinary approach is used, along with specific knowledge from various engineering sciences, including construction, robotics and information technology. The program that can be designed to train the blue-collar worker is an eight-month course in robotics and management strategies. After being certified, the worker would need to report to special classes twice every year. The special classes will be designed to introduce advancements in the technology of robots. The professors that will be used to instruct and train the workers will be management and engineering specialist. To make sure that construction labor rates will not be hindered by this intense training, the course will be provided during the evening hours and weekends. In the future, people who will be entering the construction field will be required to have a college education and it will be the responsibility of the university to make sure that the management, robotics and mechanical engineering courses are added to the Building Construction's curriculum.

The negative image of construction has led to severe shortages of skilled workers, increasing wages and thus increasing the cost of construction (Everett 1994). To change this attitude we will establish counselors, with human resource backgrounds, to come and share with the workers all of the great benefits that come with adding a new member to the team (Everett 1994). National and local seminars will also be held to give all workers hands on experience to the new technology. The Japanese have used this type of system all over their country (Hasegawa 1998). In contrast to the United States, the Japanese public holds strong negative images of labor disputes. Good relationships with the unions are vital in management's maintaining an image of the company. The Japanese workers have positive attitudes towards automation and robotics.

In the United States, there is little social demand for construction robots. Neither the government nor the construction industry appears to have much interest in supporting research and developing or helping promote higher education in construction technologies (Hasegawa 1988). Studies indicate, that besides the threat of jobs being lost, the United States feels that it would lose money trying to make the number of machines to fill the demand. In addition they feel that it would be impossible to attempt to educate workers who have been working in the field for more than ten years. Japan has accomplished this goal by allowing special tax treatment for automation and robotics research and development. The Big Five contractors of Japan invest over $100 million per year in research and development, though not all in automation and robotics (Hasegawa 1988).

Conclusion

Contradicting opinions on the future of skilled labor in conjunction with the implementation of robots in construction have led to uncertainties as to the future roles of human labor. This paper has established two opposing views of what new task and skills can be expected of human construction workers as robotics plays a greater role in construction. By addressing the increasing simplicity of task and potential for improved robot interfaces, labor concerns of how laborers can cope with changes in their roles can be greatly diminished and the acceptance of robots increased. The two contradictory viewpoints established that, while there are legitimate concerns as to the changes in skills, humans will ultimately have a little adjustment to make in order to prepare themselves for training. . Based on the data collected in this research, there is a way to increase interest between humans and robots, thereby increasing the need for labor and higher education.

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