Wearable Robotics, Industrial Robots and Construction Worker's Safety and Health

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Abstract. Workers' health always has an indispensable relationship with safety at work. Many different approaches are implemented on sites to improve workers' health condition. In this research study, we review robot and wearable robotics' applications on construction workers. Although there are many different types of robotic tools on sites, we conduct studies on some of the most updated tools such as high-tech robotic equipment.

Keywords: Wearable robotics · Ergonomic tool arms · Construction Safety · Health

1 Introduction

A myriad of dangerous and clumsy environmental factors in construction industry leads to poor and unsafe working conditions on sites. Besides, workers' fatigues due to long working hours and human errors are common causes that lead to construction accidents [1, 2]. In view of these, various types of robots are developed to alleviate the workers' health problems so as the various safety issues.

Robots can be applied in different kinds of construction projects on sites. They are used for placing concrete, lifting steel bars, spraying the exterior wall, window and floor cleaning [3]. Adopting robotic systems has a wide range of merit, for instance, better quality, productivity and safety. Employing robotic technologies accelerates the construction of high-rise buildings, which is also the current trend in the construction industry [4].

Japan is one of the leading country in applying robotic systems to automate construction tasks. SMART system (Shimizu Co.), ABCS system (Obayashi Co.), T-UP method (Taisei Co.), AMURAD system (Kajima Co.), and ROOF PUSH-UP construction method (Takenaka Co.) are the implementation of construction factory in the construction automation [4].

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2 Three Types of Robots in the Construction Industry

2.1 Traditional Robots

Controlled by computers or other kinds of stimulus on site, robots are used to construct the superstructure of buildings autonomously [5]. Different types of robots are used in different types of construction. For example, climbing robots have been used in tall building maintenance, bridge and highways maintenance [6]. The underwater construction robot for heavy work is driven by a hydraulic system which is robust to external impact [7]. Likewise, installation of heavy building materials such as exterior curtain wall panels is often hazardous and complicated, a large amount of manpower is often needed traditionally [8]. Robots for installing window panels can help. Hence In recent year, robot is applied in various kinds of construction process on site (Table 1):

Table 1. Construction and infrastructure activities with the help of robots [9].

Types of construction activities	Example
Infrastructure	Road construction
	Tunneling
	Bridge construction
	Construction and deconstruction of power plants and dams, power plants
	Container port
Construction	Vertically and horizontally oriented buildings
	Housing construction
	Construction in artic zones, sea and deep sea, space, desert
	Building service and maintenance

2.2 Wearable Robotics

AWN-03. The AWN-03 provides back support, senses workers' motion and sends a signal to motors which rotate the gears [10]. The Suit AWN-03 embraces user's shoulder, waist and thigh [11]. In essence, it assists workers' movement when they lift and hold heavy items. It raises worker's upper body support, pushes their thighs and reduces workers' lower back stress by 15 kg [10].

The battery power pack last for six hours and each of the robot suit is sold for about (US$8,100). It is expected that there is an increase in demand for AWN-03 amid the labor shortage problems and graying of workers in the construction industries [11] (Fig. 1).

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Fig. 1. Panasonic ActiveLink AWN-03 [10]

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FORTIS Exoskeleton. Another wearable exoskeleton FORTIS strengthens users' strength; and costume. Similar to Iron Man, the tool is unpowered and light in weight. The external structure enhances user's endurance. It provides advantages to workers when they lifting heavy loads such as rebar and use industrial tools. It is configured to transfer loads through the skeleton to the ground when the workers stand or kneel. It creates a weightlessness feeling when wearers are maneuvering or carrying heavy objects. The exoskeleton's ergonomic design moves naturally with the wearer and able to adapt to different body heights and types [12]. Capable of supporting up to a thirty-six-pound tool, it is designed to the bucket of a cherry picker or a man lift. It is used to

Fig. 2. FORTIS exoskeleton [13]

support large tools which may be fatigue to operate horizontally and overhead such as demo hammers, grinders, rivet busters etc [13] (Fig. 2).

Robotic Arms. Signma Ergonomics [14] suggests that a range of ergonomic tool arms has been designed to to weightlessly maneuver heavy tools. The arms rely on spring tension to balance the weight of tools used for sanding, riveting, drilling and so on. The Ekso Bionics Zero G arms can hold up to 19 kg and balance the weight. Hence, it allows the user to accurately, freely and safely maneuver the load in any direction without fatigue or injury. The ergonomic tool arms have vast numbers of mounting options which suit various different types of works such as portable gantry's carts, linear rail and jib arms. These systems require little maintenance, inexpensive inputs such as compressed air or electricity (Fig. 3).

Fig. 3. Ekso Bionics Zero G arms [14]

3 Robots in Construction Industry

Heaps of the robots were related to industrial applications between 1960s' and 90s'. They were mainly used to rationalize manufacturing production. Modern robots are ubiquitous and robust. They support, nurse and accompany humans. The US market is expected to grow at 15 percent annually while the Chinese market will increase by 17 percent. Service robot market has become more important in the first decade in the 21st century [15].

4 Application of Wearable Robotics in Hong Kong Construction Industry

One of the largest Hong Kong local construction firm has applied robot to reduce the number of workers, enhance the productivity and safety. In Murray Building Hotel

Redevelopment project, the installation robot reduced the number of workers on site by 25%. Gammon Construction also purchased two sets of exoskeleton from Japan which protect their workers improve the efficiency and reduce risk. It is good to protect worker's back and waist in long period of time. However, the cost of these technology are high, it is hard for small-size company to use these technology [16].

Many of the workers in construction industry are older than 50 years old in Hong Kong. In view of the wearable robotics such as exoskeleton and robotic arm's ability to reduce strain and lighten heavy loads, applications of these tools inevitably benefit the older workers. As robotics technology continues to develop, coupled with the rapid development in programming and robot maintenance techniques, this certainly opens up new opportunity for younger staff, who are often considered to be the group that welcome the modern technology to look for innovative applications such as wearable robots [16].

Nevertheless, some workers worry that robots eventually take jobs away from us or lead to some of the scenarios in a science fiction movie. Yet, many countries and cities in the developed world experience the problem of labor shortage as less people enter the industry. Therefore, robots are simply doing their jobs in filling the gap left by due to a dwindling workforce [16].

5 Conclusion

In the modern days, robots are used on sites for structural and maintenance work, window panel installation and under water construction works. They can do high hazardous works on sites and save much labour costs. Wearable robotics raises worker's upper body and reduces workers' lower back stress. Robotic tool arms give strengths to workers and reduce workers' fatigue. As many of the construction happen on sites due to fatigue and difficult works, various types of robotic equipment reduce the likelihood of accidents on sites. Despite some workers may worry that workers will be replaced by robots and are unemployed, developed countries or cities often face the problems of labour shortage, this certainly provides a solution for construction companies and workers can work for the less hazardous work. On the other hand, wearable robotics fastens the pace of works, make them work more efficiently; reduce the workers back or arm force and the likelihood of accidents due to fatigue.

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