



Development Opportunities of Exoskeletons

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Low birth rates and population aging are growing problems in developed and emerging industrialized countries. The medical equipment industry in Taiwan is expected to leverage the strength of local ICT and medical industries to develop products to assist immobile patients or improve life quality of the grey-haired. The global market is expected to be tremendous in the combination of medical equipment and intelligent robots.

I. Exoskeletons Revolutionize Human Mobility

Exoskeletal systems are defined as the skeletal system outside the human body to support and protect limbs. The exoskeleton robots developed by the Mechanical and Systems Research Laboratories, Industrial Technology Research Institute are a lower limb orthosis, to adjust the lower limb structure and functions. The design of this apparatus can be bespoke, to cater to specific requirements of individuals. Different from traditional support devices without powering such as cranes and walking sticks, exoskeletons are the mechanical system to enhance the functionality of human skeleton and muscles by sharing stress.

Since 2011, the Institute of Electrical and Electronics Engineers (IEEE) has been organizing academic seminars on the application of robots in medicare, and highlighting the focus in the development of medical robots and lower limb machines in the U.S. and the rest of the world. Top universities, particularly in Japan, and research institutes overseas have been developing wearables and sensor modules, and applying these components in lower limb machines. Aiming to assist and strengthen human mobility, exoskeleton robots are the complex exoskeleton

mechanical system that combines wearable sensors and drive elements.

Exoskeletons are humanoid and robotic structures, equipped with sensors and actuators to enable control. Wearable exoskeletons can be divided into stationary and mobile applications:

1. Stationary exoskeletons

Lokomat, a lower limb therapeutic machine manufactured by Hocoma in Switzerland, is an example of stationary exoskeletons. More than 500 Lokomats have been sold worldwide, mainly to medical institutions. Taipei Medical University Hospital also has one Lokomat in its Rehabilitation Division. According to Hocoma, Lokomat is a fully automated gait therapy and assessment system with physiological feedback. It provides appropriate mobility training sessions, according to the physical status of the patients. For example, patients are trained to grab an object with arms, play games with fingers or walk with lower limbs. The purpose is to prevent amyotrophy by stimulating the body. The virtual-reality interface makes physical therapy fun to patients. Locomat is suitable for patients who have suffered strokes or have spinal injuries, traumatic brain injuries, multiple sclerosis and cerebral palsy.

2. Mobile exoskeletons

Mobile exoskeletons are wearables to empower, enhance and enable limb mobility anytime and anywhere. Honda, Cyberdyne and Yaskawa from Japan, REX from New Zealand, Ekso Bionics from the U.S. and Argo Medical Technologies from Israel have launched similar products. Mobile exoskeletons serve to empower, enhance and



compensate limb mobility. The majority of the products under development are targeting at the segment of mobility compensation.



Figure 1. Lokomat, a therapeutic robot manufactured by Hocoma in Switzerland. Source: Hocoma.



Figure 2. Exoskeleton developed by ITRI. Source: Mechanical and Systems Research Laboratories, Industrial Technology Research Institute.

II. Global Market Size for Limb Rehabilitation

The global demand for robots in limb rehabilitation is expected to grow from \$43 million in 2013 to \$1.8 billion

in 2020. The development of robotic devices for lower limb immobility provides an opportunity to transform the manufacturers-centric business model of pay-by-device to service-providers-centric business model of pay-by-performance. This technology promises to enable old people and spinal cord injury (SCI) patients to be fully mobile. It will also benefit the medical practitioners and electromechanical and ICT industries.

According to the statistics from the Ministry of the Interior, the number of people in Taiwan that require long-term Medicare increases by 300,000 on average each year. This has resulted in a serious shortage of medical caretakers. The assistance from medical supporting devices for repetitive, tedious and labour-intensive tasks will reduce the workload of medical professionals.

The application of robots in medical care will also create inter-disciplinary demand for the electromechanical and ICT industries. This will help the upgrade and transformation of the assistive medical device manufacturers and electromechanical suppliers in Taiwan.

The Industrial Economics & Knowledge Center (IEK) seeks to examine the market potential by focusing on the key drivers of the assistive medical device market. These drivers include population aging (as previously mentioned) and the growing prevalence of chronic diseases such as diabetes and cardiovascular diseases.

Population aging is a global issue and the number of old people suffering from strength loss and degeneration in muscles and the neural system is set to rise. This will continue to drive the demand for assistive medical equipment. The countries with the most serious aging problems are developed countries such as Japan and European states, with sophisticated social welfare systems and strong demand for quality of life. The availability of medical insurance and policy support means pricy medical equipment for mobility assistance is in demand. These geographic markets are where Taiwanese manufacturers should focus on.

Meanwhile, chronic diseases (such as diabetes and cardiovascular diseases) continue to threaten human health. Diabetes has become the major cause of amputations in the developed world. According to estimates from the World Health Organization, the number of diabetes patients may increase in folds after 2015. Whilst medical advancement and better medical knowledge base can reduce the percentage of required amputations, diabetes remains a key driver for the demand for medical assistive devices. Cardiovascular diseases have also become a major health problem triggered by overeating, stressful life, aging and diabetes. Patients often suffer mobility difficulties. It is particularly the case with patients whose central nervous systems have been damaged due to cerebral strokes.

In sum, as population aging and chronic diseases are inevitably becoming a global problem, the demand for exoskeletons in mobility assistance is expected to grow exponentially.

III. Integration of Technological Resources from Academics, Industry and Research Institutes as Development Momentum

Taiwanese suppliers of artificial limbs have laid down a solid foundation and have experience in the Chinese market. However, the development of exoskeletons requires knowhow in mechanical designs, chip processing, sensing and man-machine interface. The good news is that Taiwan has developed extensive competences among academic and research institutions, electronics manufacturers and high-precision machinery suppliers. However, there is no mechanism in place yet to integrate the resources and capabilities in industries, academics and research organizations. An alliance is required to put together all the complementary knowhow and skillsets as the foundation for the industry development.

Assistive medical apparatuses serving mobility-challenged patients come in a large variety but small volumes, as personalization is required. It is hence important to prioritize resources in the areas most promising to Taiwanese players, who are relatively less experienced in R&D and marketing. It is also essential for domestic manufacturers and R&D organizations to carefully evaluate the feasibility before investing human and technical resources. The government should provide a suite of solutions and policy schemes to assist the

industry development. The success of any products requires the combination of technical and marketing resources and the identification of target segments.

It is necessary to understand technical issues and non-technical issues, such as social welfare and rehabilitation systems, associated with the development of exoskeletons as a medical product. The demand for assistive medical instruments is highly related to hospitals and rehabilitation service providers. In fact, the installation of artificial limbs or assistive apparatuses requires comprehensive professional services. Whilst R&D efforts are a critical factor, the commercial activities in relation to services play a pivotal role in product launch. The technological development is only one of the key successful factors.

There are very few exoskeletons for mobility assistance in the marketplace. In Taiwan, there is no precedent case in terms of application procedures for health insurance. It is necessary to provide additional evidence to prove the safety and effects of the products. Medical device certificates, results of human tests and evidence of health benefits are required for any product to attract meaningful subsidies and insurance coverage in Taiwan. It is important to come up with reasonable budgets before subsidies so that the products concerned can have high market shares if subsidies. The integration with R&D results from the likes of Industrial Technology Research Institute should be most effective way to develop exoskeleton products in Taiwan.

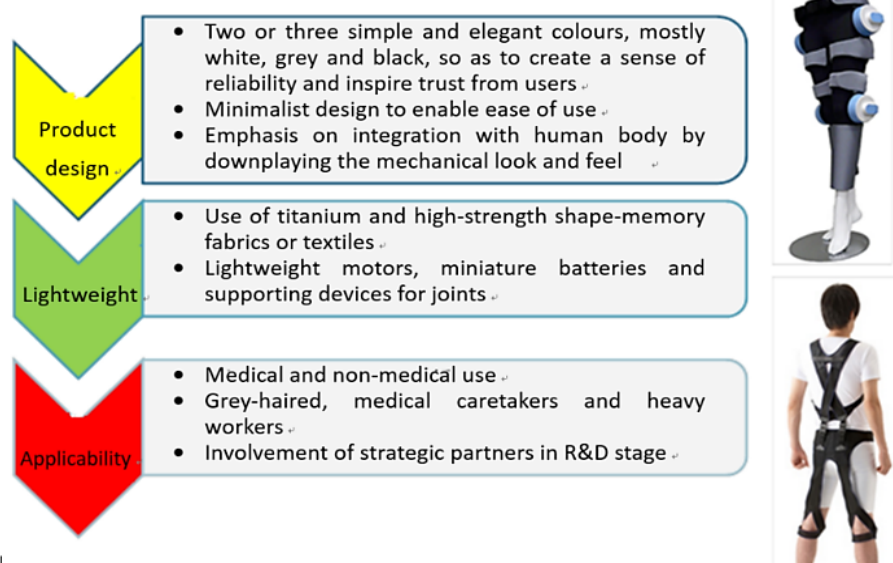


Figure 3. Exoskeleton Product Development & Trends. Source: Industrial Economics & Knowledge Center, ITRI.