POWERED EXOSKELETONS

1. A powered exoskeleton (also known as power armor, powered armor, powered suit, exoframe) is a wearable mobile machine that is powered by a system of electric motors, pneumatics, levers, hydraulics, or a combination of technologies that allow for limb movement with increased strength and endurance. Its design aims to provide back support, sense the user's motion, and send a signal to motors which manage the gears. The exoskeleton supports the shoulder, waist and thigh, and assists movement for lifting and holding heavy items, while lowering back stress.

History

2. An innovative system, in which sensors detect contractions of a human user's muscles and use them to operate a series of valves, which in turn regulate the flow of high-pressure hydraulic fluid to the joints, has been developed. Those mechanical joints then move cylinders with cables attached to them to simulate the tendons that attach human muscle.

3. Meanwhile, other outfits, such as Berkeley Bionics, worked on reducing the amount of energy that artificial limbs require, so that a powered exoskeleton could function long enough in the field to be practical. One mid-2000s design, the Human Load Carrier, reportedly was capable of operating for 20 hours without recharging.
4. Near the end of the decade, a Japanese company called Cyberdyne developed the Robot Suit HAL, an even more ingenious concept. Instead of relying on a human operator's muscle contractions to move the limbs, HAL incorporated sensors that picked up the electrical messages sent by the operator's brain. Theoretically, an exoskeleton based on the HAL-5 concept would enable a user to do whatever he or she wanted without moving a muscle, simply by thinking about it.

5. The current systems, which weigh about 55 pounds (25 kilograms), can enable human operators to carry 200 pounds (91 kilograms) of weight with little or no effort and dramatically less fatigue. Additionally, the latest exoskeletons are quieter than the typical office printer, and can run at speeds of 10 miles per hour (16 kilometers per hour) and perform squats and crawls, in addition to lifting.

Technical aspects

Power supply

6 One of the biggest problems facing engineers and designers of powered exoskeletons is the power supply. This is a particular issue if the exoskeleton is intended to be worn "in the field", i.e. outside a context in which the exoskeleton can be tethered to a power source. Batteries require frequent replacement or recharging, and may risk explosion due to thermal runaway. Internal combustion engine power supplies offer high energy output, but problems include exhaust fumes, heat and inability to modulate power smoothly. Hydrogen cells have been used in some prototypes but also suffer from several problems.

Materials

7 Early exoskeletons used inexpensive and easy-to-mold materials, such as steel and aluminium. However, steel is heavy and the powered exoskeleton must work harder to overcome its own weight, reducing efficiency. Aluminium alloys are lightweight, but fail through fatigue quickly. Fiberglass, carbon fiber and carbon nanotubes have considerably higher strength per weight. "Soft" exoskeletons that attach motors and control devices to flexible clothing are also under development.

Actuators

8 Joint actuators also face the challenge of being lightweight, yet powerful. Technologies used include pneumatic activators, hydraulic cylinders, and electronic servomotors. Elastic actuators are being investigated to simulate control of stiffness in human limbs and provide touch perception. The air muscle, a.k.a. braided pneumatic actuator or McKibben air muscle, is also used to enhance tactile feedback.

Joint flexibility

9 The flexibility of human anatomy is a design issue for traditional "hard" robots. Several human joints such as the hips and shoulders are ball and socket joints, with the center of rotation inside the body. Since no two individuals are exactly alike, fully mimicking the degrees of freedom of a joint is not possible. Instead, the exoskeleton joint is commonly modeled as a series of hinges with one degree of freedom for each of the dominant rotations.

Applications

Medical

10 Powered exoskeletons can improve the quality of life of individuals who have lost the use of their legs by enabling system-assisted walking. Exoskeletons — that may be called "step rehabilitation robots" — may also help with the rehabilitation from stroke, spinal cord injury, neuromuscular diseases or during aging. Several prototype exoskeletons are under development. Exoskeleton technology is also being developed to enhance precision during surgery, and to help nurses move and carry heavy patients. Berkeley Bionics, for example, is testing eLegs, an exoskeleton powered by a rechargeable battery, which is designed to enable a disabled person to walk, to get up from a sitting position without assistance, and to stand for an extended period of time.

Military

11 A variety of "slimmed-down" exoskeletons have been developed for use on the battlefield, aimed at decreasing fatigue and increasing productivity, to support soldiers in performing tasks that are "knee-intensive", such as crossing difficult terrain. They can reduce a soldier's response time. These exoskeletal machines would also be equipped with sensors and Global Positioning System (GPS) receivers. Soldiers could use this technology to obtain information about the terrain they're crossing and how to navigate their way to specific locations. Computerized fabrics, that could be used with the exoskeletons to monitor heart and breathing rates, are also being developed.

Civilian

12 Exoskeletons are being developed to help firefighters and other rescue workers to climb stairs carrying heavy equipment.

Industry

13 Passive exoskeleton technology is increasingly being used in the automotive industry, with the goal of reducing worker injury (especially in the shoulders and spine) and reducing errors due to fatigue. These systems can be divided into two categories:

- exoskeletons for upper-limb for assisting shoulder flexion-extension movements;
- exoskeletons for lumbar support for assisting manual lifting tasks.

14 For broadest application, industrial exoskeletons must be lightweight, comfortable, safe, and minimally disruptive to the environment. For some applications, single-joint exoskeletons (i.e. intended to assist only the limb involved in specific tasks) are more appropriate than full-body powered suits. Full-body powered exoskeletons have been developed to assist with heavy loads in the industrial setting, and for specialized applications such as nuclear power plant maintenance.

Exercises

Match the words to make collocations.

1. innovative (par. 2)	a) fabrics
2. artificial (par. 3)	b) exoskeleton
3. ingenious (par. 4)	c) exoskeleton
4. muscle (par. 4)	d) feedback
5. incorporated (par. 4)	e) battery
6. power (par. 6)	f) walking
7. thermal (par. 6)	g) concept
8. exhaust (par. 7)	h) system
9. tactile (par. 9)	i) contractions
10. system-assisted (par. 10)	j) limbs
11. rechargeable (par. 10)	k) sesnors
12. computerized (par. 11)	l) fumes
13. single-joint (par. 14)	m) runaway
14. full body (par. 14)	n) supply

Match the words with their Polish translations. The words are underlined in the text.

1. endurance	a) przezwyciężyć
2. limb	b) rdzeń kręgowy
3. contraction	c) ulepszyć
4. valve	d) kręgosłup
5. tendon	e) destrukcyjny, zakłócający
6. artificial	f) wytrzymałość
7. ingenious	g) zawór
8. enable	h) zawias
9. fatigue	i) kończyna
10. tether	j) udar
11. overcome	k) skurcz
12. efficiency	l) zgięcie
13. enhance	m) lędźwiowy
14. tactile	n) sztuczny
15. hinge	o) podłączyć
16. stroke	p) zmęczenie
17. spinal cord	q) wyprostowanie
18. fabric	r) ścięgno
19. spine	s) dotykowy
20. flexion	t) pomysłowy
21. extension	u) wydajność
22. lumbar	v) tkanina
23. disruptive to	w) umożliwić

Match the words with their definitions.

1. internal combustion engine	a. rotary or linear actuator that allows for precise control of angular or linear position, velocity and acceleration
2. hydrogen cells	b. a material consisting of thin, strong crystalline filaments of carbon, used as a strengthening material, especially in resins and ceramics
3. fibreglass	c. a device which converts the energy stored in the hydraulic fluid into a force used to move the cylinder in a linear direction
4. carbon fibre	d. a device which converts energy into mechanical motion
5. carbon nanotubes	e. fuel cells which undergo a chemical process to convert hydrogen-rich fuel into electricity.
6. pneumatic actuator	f. an engine in which the process of combustion takes place in a cylinder, the working fluid is a fuel and air mixture, which reacts to form combustion products and is then exhausted
7. hydraulic cylinder	g. large molecules of pure carbon that are long and thin, about 1-3 nanometers (1 nm = 1 billionth of a meter) in diameter, and hundreds to thousands of nanometers long. as individual molecules, they are 100 times stronger-than-steel and one-sixth its weight.
8. servomotor	h. a strong, light material made by twisting together small threads of glass and plastic

Answer the questions.

1. What is an exoskeleton?
2. Which parts of the body does it support?
3. In what way does it imitate humans?
4. Which human movements can it perform?
5. What kinds of power supply can be used?
6. What materials have been used in exoskeletons?
7. What technologies have been used to imitate human joints?
8. Explain the applications of:
    a) medical exoskeletons
    b) military exoskeletons
    c) industrial exoskeletons.

Complete the gaps with the correct preposition – a, an, the, -.

1. Berkeley Bionics, worked on reducing ______ amount of energy that ______ artificial limbs require, so that ______ powered exoskeleton could function long enough in ______ field
2. Near ______ end of ______ decade, ______ Japanese company called Cyberdyne developed _______ Robot Suit HAL, _______ even more ingenious concept.
3. One of ______ biggest problems facing ______ engineers and designers of powered exoskeletons is ______ power supply.
4. This is ______ particular issue if ______ exoskeleton is intended to be worn in ______ field.
5. eLegs, ______ exoskeleton powered by ______ rechargeable battery, which is designed to enable ______ disabled person to walk, to get up from ______ sitting position without assistance, and to stand for ______ extended period of ______ time

Match the words with their pronunciation. Then practice reading them.

1. pneumatic	a) /mʌs(ə)l/
2. wearable	b) /fəti:ɡ/
3. endurance	c) /kəmbʌstʃ(ə)n/
4. muscle	d) /ɪɡzɔ:st/
5. hydraulic	e) /nju:mætɪk/
6. fatigue	f) /lʌmbə(r)/
7. tether	g) /haɪdrədʒən/
8. combustion	h) /weərəb(ə)l/
9. exhaust	i) /haɪdrɔ:lɪk/
10. hydrogen	j) /ɪndjʊərəns/
11. lumbar	k) /teðə(r)/

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