



## Father's Day 2019 + (Patent Landscaping + (Biomedical Engineering and Robotics))

June 17, 2019

### **Father's Day 2019**

We celebrated Father's Day a little differently this year compared to in years past. A highlight of the holiday is usually centered around playing golf with my dad or some other active adventure with my own children. Father's Day this year was bittersweet as we celebrated a new life with my dad following a spinal stroke that he suffered in April. The most obvious and life changing impact of the spinal stroke is complete paralysis from his mid-abdomen to his feet with little to no sign of anticipated recovery or physical improvement. Unexpectedly, life has changed into a series of thankful blessings. We are so thankful that he is still with us and are especially thankful that he has maintained his wits, thoughts and humor (and full use of the top half of his body). This life change certainly brings on new challenges of adapting to each day to come, including accessibility issues, living with a wheelchair and other physical assistance products. Yet with all the new challenges and uncertainty for the future, we are truly thankful for the blessings that we have and are hopeful for the new memories that we will make with my father in the coming years.

My dad is undergoing intensive physical rehab at The Shepherd Center in Atlanta ([link](#)). The facility is great and is very well known for their innovative treatments, research and overall care. Our time at The Shepherd Center has brought many thoughts to the forefront of my daily mental load, generally falling into these three categories: 1) the body and spinal cord is far more complex and precious than I ever could have imagined, 2) be thankful that my dad is alive considering that so many people at Shepherd are much more worse off and 3) always try to look for hope and positivity in any situation. Our highlight of Father's Day this year was that my dad successfully earned a "push pass" so that he (and his wheelchair) could leave the building on his own (without Shepherd Center staff) and enjoy a meal outside of the normal schedule. It was his second meal out in 3 months and although it wore him out, we all enjoyed it tremendously.

Throughout the last few months, I have been intrigued by the equipment that The Shepherd Center uses (or could use) for physical rehab, the innovation programs and the overall state of new technology trends in the field of physical mobility for people with spinal injuries. As a result, I have started researching patenting activities in the fields of mobility, robotics and exoskeletons with the optimism that one day my dad will be walking again – likely with some pretty cool technology to help. Hence, Adapt IP Ventures will be watching these companies, IP, funding and product announcements intently and optimistically with the hope that one day, my father will be able to utilize this innovation to hopefully be able to walk again (albeit likely with some fancy assistance).

**I always knew my dad was a super hero but I never expected him to be Iron Man. Happy Father's Day to all the dads out there!**

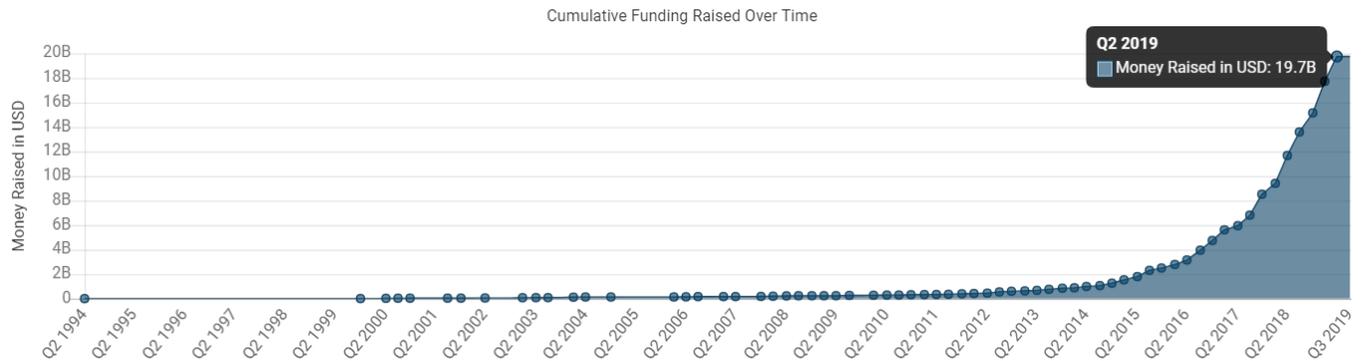
---

Below you will find an overview of initial findings, trends and activity related to Healthcare Assistive Robotics broken down into the following categories:

1. Market Overview
2. Patent Landscape

## Healthcare Assistive Robotics Market Overview

Investments in robotics technologies has been considerable over the last 10 years with an estimated ~\$20B being poured into related technologies according to Crunchbase data ([link](#)). Funding to robotics-related organizations has exploded in the last 3-4 years with the majority of fundraising taking place during this recent timeframe.



One important subset of the robotics market is healthcare-related assistive technologies. The Global Healthcare Assistive Market is set to exceed \$1.2B by 2024 according to Global Market Insights. ([link](#)). Factors impacting the market growth and demand for assistive robotic products and technologies include: 1) increasing incidence of stroke with an estimated 5 million people remaining permanently disabled annually, 2) ability of assistive robots to perform repetitive sets of exercises and provision of measurable feedback and 3) generally consistent population of traumatic injury patients with spinal cord injuries.

Interestingly, the Global Market Insights report cites Japan as a leading geographic market for healthcare assistive robotics, primarily driven by the country's favorable support for such initiatives including "Society 5.0" and "Robot Revolution Initiative" campaigns. ([link](#)) More to come on this observation.

## Patent Landscaping + (Biomedical Engineering and Robotics)

This introductory assessment of the assistive robotics market serves as a primer to introduce many of the innovative companies and their patent investment and filing trends. The purpose of this analysis is to begin to establish an understanding of innovators in this new field to be better educated on the companies developing life changing technologies to hopefully improve the daily lives and recoveries of patients. Significant research and analysis should be performed before any additional actions or considerations emerge from this posting.

Key technology concepts for assistive robotics:

- Motion assistance and control: (human, human + machine, machine)
- Form factor (full body, one leg/two legs, convenience features, etc.)
- Material (carbon fiber, various metals, titanium, plastic, etc.)
- Connectivity: (Measuring and monitoring of location, movement, etc.; therapeutic movement and repetition management; wireless transmission/built-in storage, gamification)

## Patent Landscaping Setup

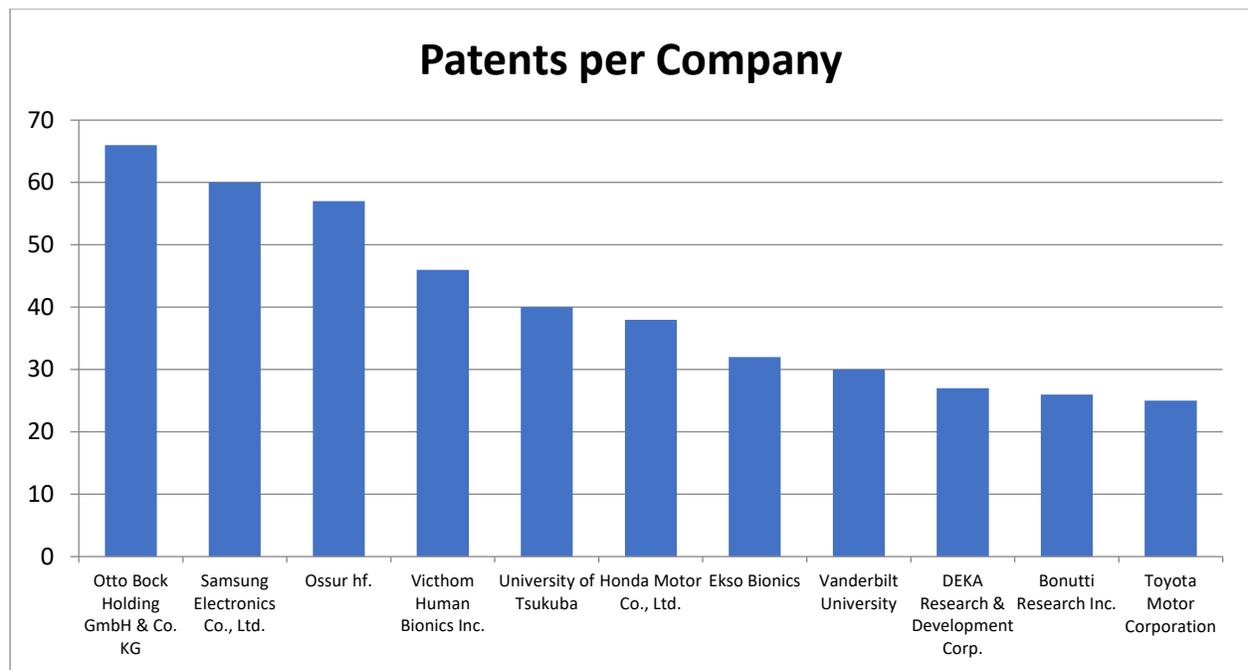
Data identified and organized via the IP research platform, Innography ([www.innography.com](http://www.innography.com)).

- Began Started search and analysis with collecting IP from three of the “pure play” assistive robotics companies (Ekso + Cyberdyne + ReWalk (analyzing top 100 of 438 patents))
  - Expanded by “Recommended by classification” -> 168,203 total assets returned
    - Refined by only considering “Active” patent assets ->63,598 assets (13,452 organizations) returned
      - Refined by applying “Similarity” rating scale (4) – 2,775 patents (913 organizations)

## Top Patent Holders

The diversity of companies investing in patent filings in this field is significant, ranging from pure play walking assistance / therapeutic development companies to larger diversified industrial, transportation and technology companies. This is logical and appreciated because solving problems in this field must combine knowledge and insights from fields including biomechanical, mechanical, electrical mobility and medicine/healthcare, among others.

Below is a representative list of companies investing in assistive robotics technologies (top 10) and the number of potentially relevant patents.





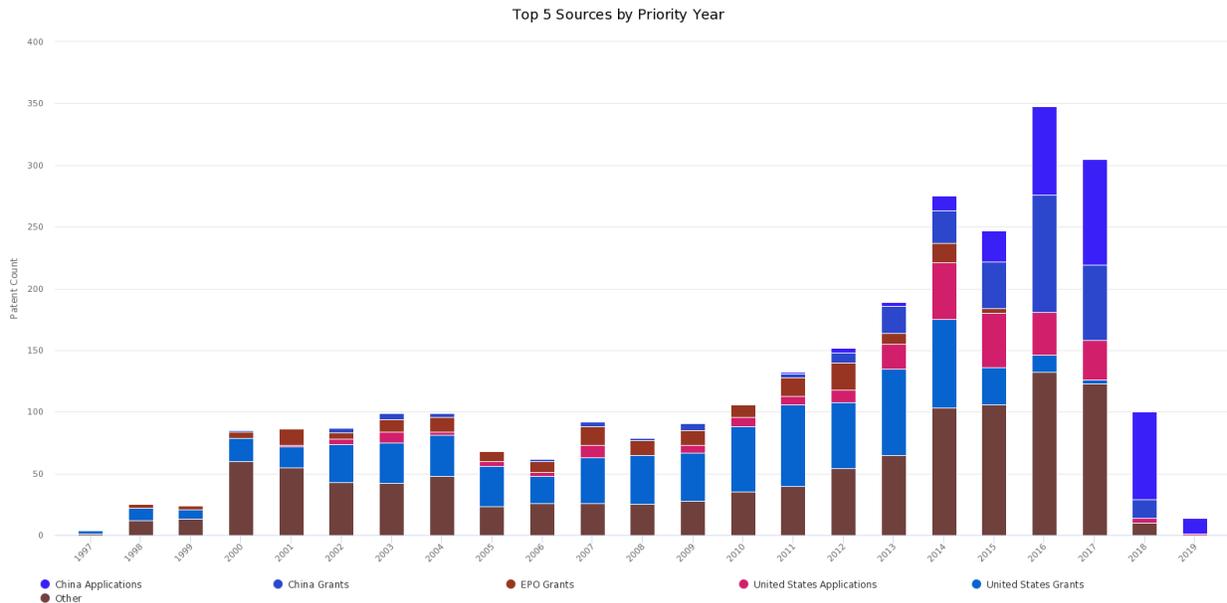
The list below expands the pool of relevant companies and the number of patents matching the search criteria.

Organization	Patents
Otto Bock Holding GmbH & Co. KG	66
Samsung Electronics Co., Ltd.	60
Ossur hf.	57
Victhom Human Bionics Inc.	46
University of Tsukuba	40
Honda Motor Co., Ltd.	38
Ekso Bionics	32
Vanderbilt University	30
DEKA Research & Development Corp.	27
Bonutti Research Inc.	26
Toyota Motor Corporation	25
University Of California	25
Massachusetts Institute Of Technology	25
OTTOBOCK SE and CO. KGAA	25
Panasonic Corporation	23
Bioservo Technologies AB	19
BIONX Medical Technologies, Inc.	15
CYBERDYNE Inc	14
Atiph, Inc.	12
ReWalk Robotics Ltd.	11
Rsl Steeper Holdings Ltd.	11
Motorika Ltd., Israel	10

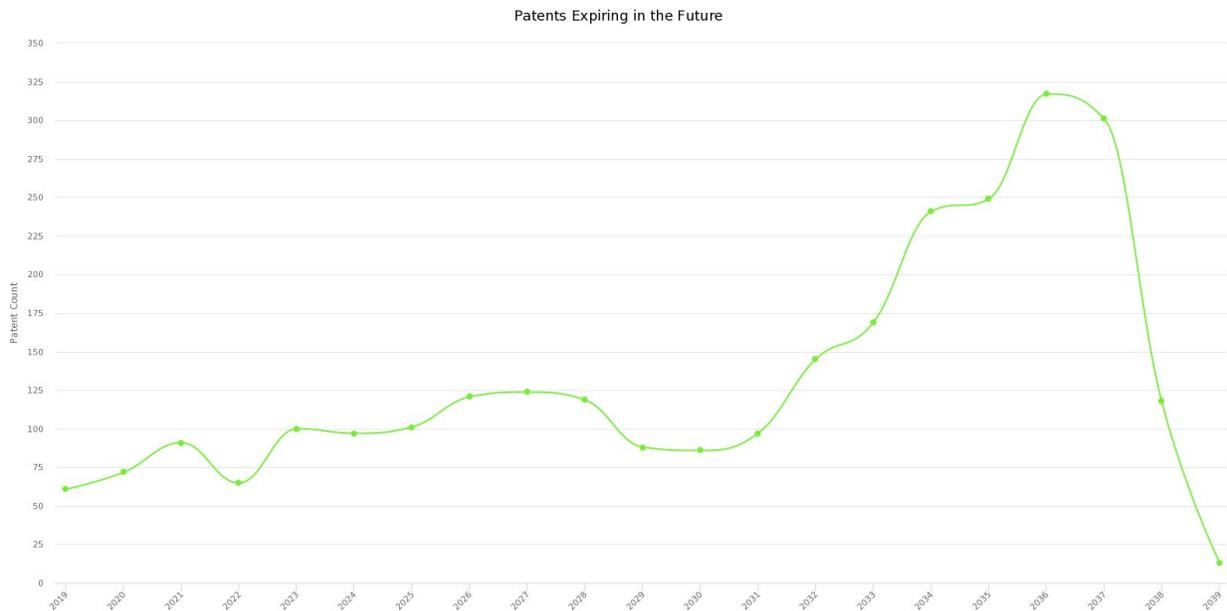
Organization	Patents
Harvard University	9
Townsend Barry W.;CLAUDINO Byron K.	8
Waud Capital Partners LLC	8
WANDERCRAFT	8
Parker-Hannifin Corporation	8
The Blackstone Group L.P.	7
Hocoma AG	7
Blatchford Products Ltd	7
Touch Bionics Limited	7
Intellectual Ventures Management, LLC	7
Seiko Epson Corporation	6
Fenf, LLC, Michigan	6
RxFUNCTION, Inc.	6
Myomo, Inc., Massachusetts	6
iWalk, Inc.	6
Commissariat à l'énergie atomique et aux énergies alternatives	6
University Of Shanghai For Science And Technology	6
CYMEDICA, INC., ARIZONA	6
HMH Ltd	6
Boston Scientific Corporation	6

### Patent Filing and Expiration Trends

To help visualize patent activity in the assistive robotics market, patent filing trends are presented below based on priority dates of patent applications filed in the 5 most active jurisdictions based on patent count from 1997 - 2019, Assets filed in the U.S., Europe and China lead the way. Note the significant growth in patent filings over the last 10 years. Also, note the decline in published patent assets with priority dates in 2018 and 2019 is most likely based on the 18-month delay in publication of filings and likely not an indication of diminished interest in the field.



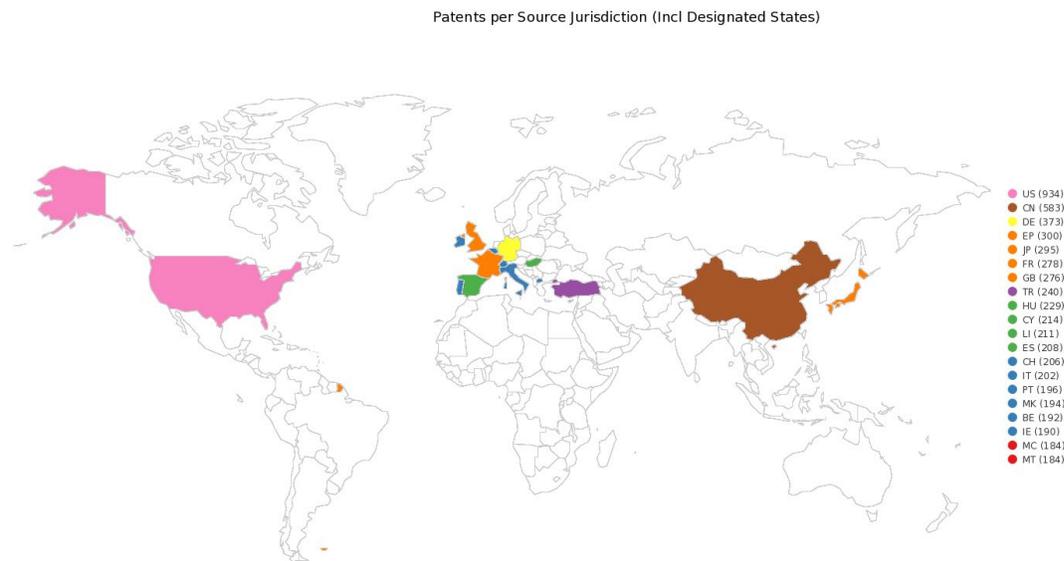
Patent filings in this market appear to be relatively recent with a large portion of patent filings expiring between 2030 and 2037. I am optimistic that these companies and others will view the long remaining patent life positively as they consider product investment decisions.



## Geographic Analysis

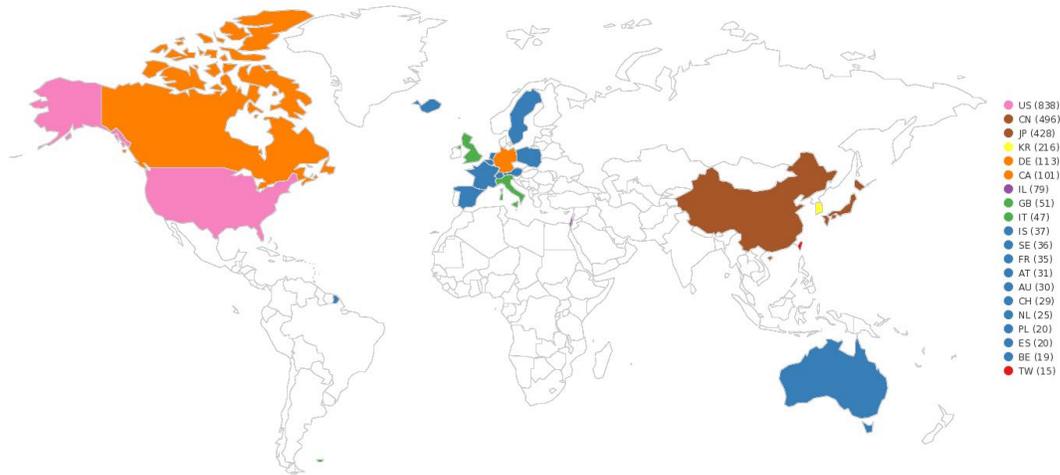
### Patent per Source Jurisdiction

Innovators in the field of assistive robotics appear to see global product opportunities and related legal protections sought as indicated by their patent filing trends. Filings in the U.S., China, various European countries, and Japan lead the geographic selection for IP investment.



Similar to the prior graphic, the location of inventors is diversified as well. Leading inventor locations include the U.S., China and Japan. The fact that Japan is a leader in the filing locations and inventor presence is not surprising considering the significant number of industrial and automotive companies and the government support for innovation programs in this field.

Patents per Inventor Location



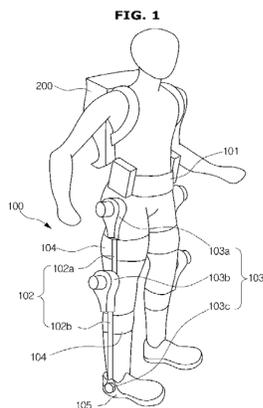
### Interesting Patents

The possibilities of development and life improvement within these companies. Below are snapshots of patents that appeared interesting from a product development perspective and are representative of the wide range of companies that are innovating in this market.

#### US9833896 – Wearable robot and method of controlling the same (Current Assignee: Samsung Electronics Co. Ltd.) - [link](#)

Abstract: There are provided a wearable robot and a method of controlling the same. The method includes obtaining a joint angle and a joint angular velocity of a plurality of joints, calculating a target joint angle of one joint among the plurality of joints using a joint angle and a joint angular velocity of at least one joint among the other joints, calculating assistive torque to be applied to the one joint using the calculated target joint angle, and outputting the calculated assistive torque to the one joint.

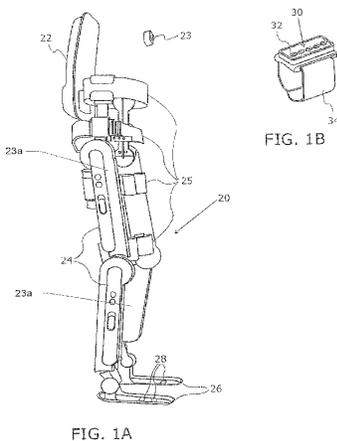
Figure 1 from the '896 patent:



**US9526668 – Locomotion assisting device and method (Current Assignee: ReWalk Robotics Ltd.) - [link](#)**

**Abstract** – An exoskeleton bracing system includes: a trunk support for affixing to the trunk of a disabled person and leg braces for connecting to the legs of the person, each leg brace including limb segment braces. Motorized joints are adapted to provide relative angular movement between the limb segment braces of the leg braces and between the leg braces and the trunk support. One or more ground force sensors are designed to sense ground force exerted on each of the leg braces. The system also includes a controller for receiving sensed signals from said one or more ground force sensors, with an algorithm for identifying a stance from the sensed signals and, based on the identified stance, actuating the motorized joints to perform an action relating to a mode of locomotion selected from a set of predefined actions corresponding to the identified stance.

Figure 1 from the '668 patent:



**US9907722 – Admittance shaping controller for exoskeleton assistance of the lower extremities (Current Assignee: Honda Motor Co., Ltd.) - [link](#)**

**Abstract** – The control method for lower-limb assistive exoskeletons assists human movement by producing a desired dynamic response on the human leg. Wearing the exoskeleton replaces the leg's natural admittance with the equivalent admittance of the coupled system formed by the leg and the exoskeleton. The control goal is to make the leg obey an admittance model defined by target values of natural frequency, resonant peak magnitude and zero-frequency response. The control achieves these objectives objective via positive feedback of the leg's angular position and angular acceleration. The method achieves simultaneous performance and robust stability through a constrained optimization that maximizes the system's gain margins while ensuring the desired location of its dominant poles.

Figure 1 from the '722 patent:

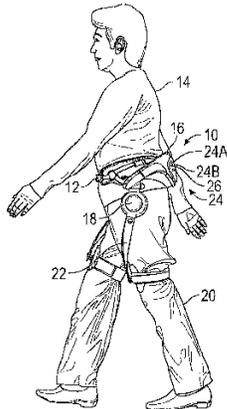


FIG. 1A

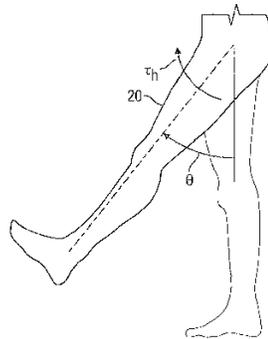
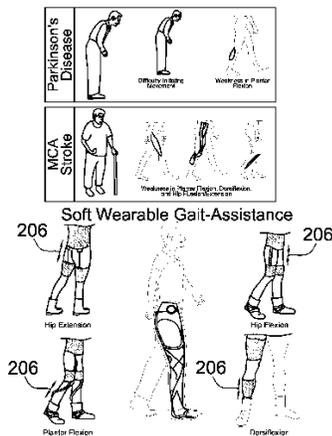


FIG. 1B

**US20170202724 – Assistive flexible suits, flexible suit systems, and methods for making and control thereof to assist human mobility - [link](#)**

Abstract - In at least some aspects, the present concepts include a method for configuring an assistive flexible suit including the acts of outfitting a person with an assistive flexible suit, monitoring an output of at least one sensor of the assistive flexible suit as the person moves in a first controlled movement environment, identifying at least one predefined gait event using the output of the at least one sensor, adjusting an actuation profile of the at least one actuator and continuing to perform the acts of monitoring, identifying and adjusting until an actuation profile of the at least one actuator generates a beneficial moment about the at least one joint to promote an improvement in gait. The at least one controller is then set to implement the actuation profile.

Figure 1 from the '724 patent application:

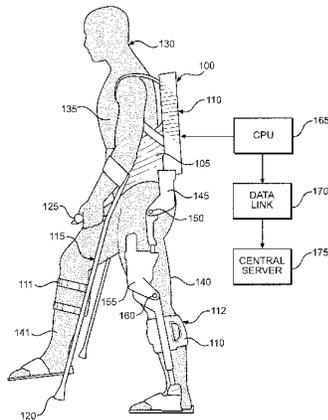


Note: May 2016 - ReWalk Announces Collaboration with Harvard University's Wyss Institute to Develop Lightweight and Soft Exoskeleton Systems for the Treatment of Stroke, Multiple Sclerosis and Limited Mobility Patients - [link](#)

**US20180092536 – Methods of exoskeleton communication and control (Current Assignee: Ekso Bionics, Inc.) - [link](#)**

Abstract – A first exoskeleton is in communication with a central server or a peripheral device. The first exoskeleton collects first data and transmits the first data to the central server or peripheral device. The central server or peripheral device generates second data using the first data and transmits the second data to the first exoskeleton or a second exoskeleton.

Figure 1 from the '536 patent application:

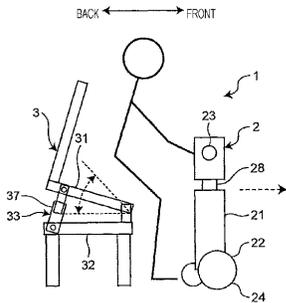


**US20170258665 – Walking assistance robot for assisting smooth start of user's action after standing up from chair (Current Assignee: Panasonic Intellectual Property Management Co., Ltd.) - [link](#)**

Abstract – A system is disclosed which includes a walking assistance robot for assisting a smooth start of a user's action after standing up from a chair. A system according to an aspect of the present disclosure includes a walking assistance robot and an automatic elevation chair that moves a seating surface where a user sits. The automatic elevation chair detects a consciousness level of the user and transmits consciousness level information on the detected consciousness level of the user to the walking assistance robot via the network. The walking assistance robot, including a body and a rotor that moves the walking assistance robot, receives the consciousness level information via the network and controls resistance force to rotation of the rotor based on the received consciousness level information.

Fig. 1 from the '665 application:

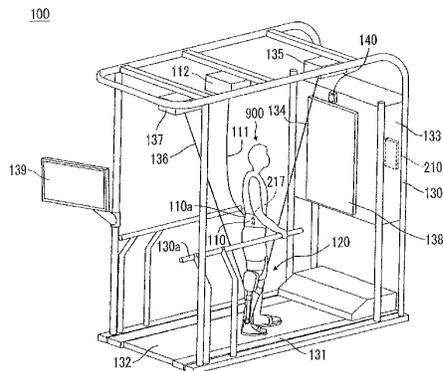
FIG. 1



**US20190150792 - Gait evaluation apparatus, gait training system, and gait evaluation method (Current Assignee: Toyota Jidosha Kabushiki Kaisha) - [link](#)**

**Abstract:** A gait evaluation apparatus that evaluates a training gait of a paralyzed patient suffering from paralysis in a leg includes an acquisition unit configured to acquire a plurality of motion amounts of a paralyzed body portion according to a gait motion and an evaluation unit configured to evaluate that the gait motion is an abnormal gait in a case where at least one of the motion amounts acquired by the acquisition unit meets any one of a plurality of abnormal gait criteria set in advance. The abnormal gait criteria include at least two or more first criteria, which are criteria relevant to motion amounts of different parts of the paralyzed body portion, or at least two or more second criteria, which are criteria relevant to motion amounts of the same part of the paralyzed body portion in different directions.

Figure 1 from the '792 patent application:



**Conclusion:**

The possibilities that innovators in the field of assistive robotics is endless and can have meaningful impact on lives around the world.