Ratchet-Pawl Integration in Full Body Mechanical Rigid Wearable Exoskeleton

Deepanker Shukla, Aryan Verma, Sarthak Yadav, Basetti Thejeswar

Deepanker Shukla
Independent Researcher
incdsg@yahoo.com
ORCID 0000-0002-3870-0761

Aryan Verma
Independent Researcher
aryanvermacoc@gmail.com
ORCID 0000-0003-0122-2871

Sarthak Yadav
Independent Researcher
Sarthakyadav2500@gmail.com
ORCID 0000-0001-7985-388X

Basetti Thejeswar
Independent Researcher
thejeswar.basetti@gmail.com
ORCID 0000-0002-9817-6949

Deepanker Shukla
Is pursuing Bachelors of Mechatronics Engineering and has gained CAD skills in the software CATIA V5 from various institutions.

Aryan Verma
Is Mechatronics Engineering Undergrad Student at KIIT, India and is adept in 3D Design, Programming and Drone Assembly.

Sarthak Yadav
Is pursuing Bachelors of Mechatronics Engineering and has gained C++, Python and SQL skills from various institutions.

Basetti Thejeswar
Is currently pursuing Bachelors of Engineering in Mechatronics and has gained CAD, C, Python skills from various institutions.

Abstract
The authors of this paper have documented the design process of certain configurations of ratchet-pawl mechanism to integrate into a full body exoskeleton with joints in such a way that the exoskeleton becomes a sort of lock for the user's body and cannot be altered/moved without the user's control while allowing maximum degree of freedom while allowing scope for further innovations. Liberties in dimensions, constraints and design process have been taken to create non totalitarian solutions for certain types of body joints and have been kept only for design and workings. To the best of our knowledge no such integration of ratchet-pawl mechanism into

mechanical wearable rigid full body exoskeleton in this certain configuration have been achieved before.

Keywords
Ratchet,
Pawl,
Exoskeleton,
Mechanical,
Design.

Background

The ratcheting socket wrench, with interchangeable sockets, was invented by an American, J.J. Richardson, of Woodstock, Vermont. The tool was patented through the Scientific American Patent Agency on June 16, 1863. The first illustration of the tool appears on p.248 of the April 16, 1864 issue of Scientific American.[1] Rigid exoskeletons can be dated back to Ancient Sumer [2][3], one of the cradles of civilization, and oldest western armours were panoply and later chainmail by design.[4]

Design process

Human body consists of different freely movable joints which have been categorized in 6 different types, namely -

1. hinge (the knee and elbow joints),
2. pivot (the joints between vertebrates),
3. gliding (the wrist joints),
4. saddle (the joint at the base of the thumb),
5. ball and socket (hip joint or shoulder joint) and
6. condyloid (the jaw or finger joints).

The researchers have designed 3 separate configurations for the end goal to be achieved.

A. Hinge configuration

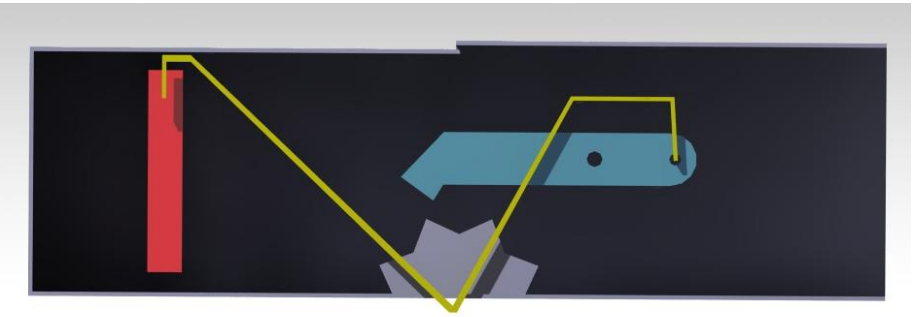


Fig.1

This configuration (illustrated in Figure 1) consists of 5 different parts, base metal encasing for the lower part of the finger (any), the movable metal encasing having ratchet wheel attached to it, the ring kept inside the second part, the wire and the pawl attached to the side of the base metal encasing. This configuration works when user intended motion gets translated by the ring and wire

to the pawl to prevent/allow movement in one or another direction thus allowing only to and fro movement.

B. Rotary Configuration

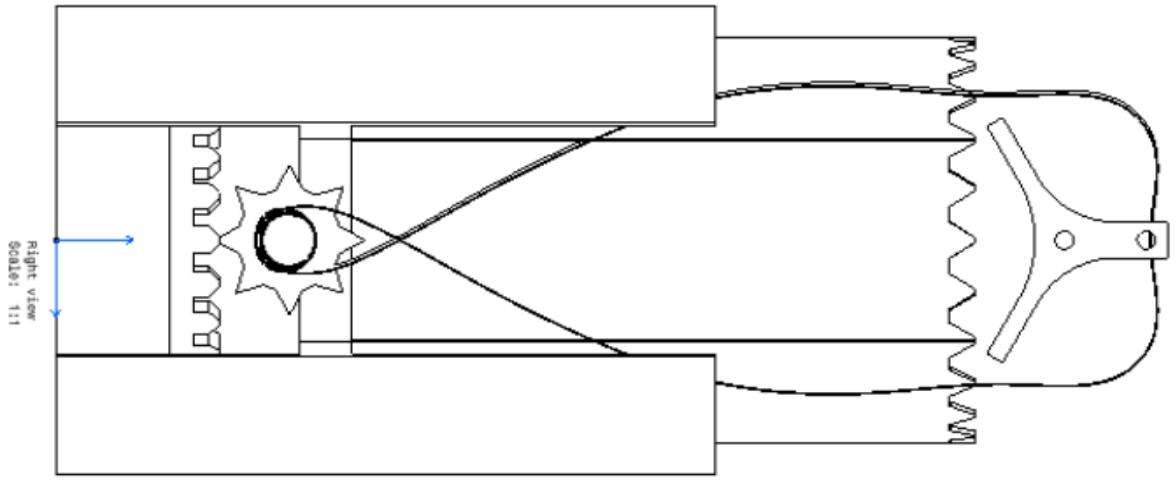
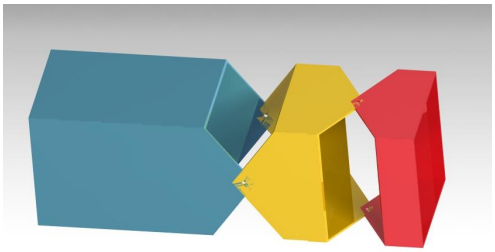


Fig.2

This configuration (illustrated in Figure 2) consists of 5 structures, base cylindrical part, movable part with ratchet teeth, pawl, two wires and the ring accompanied by gear. The ring translates users movement through gear and the wires to the pawl which prevents/allows the motion of movable part. This configuration has been designed to be used in between the wrist and the elbow and likewise.

C. Universal Configuration



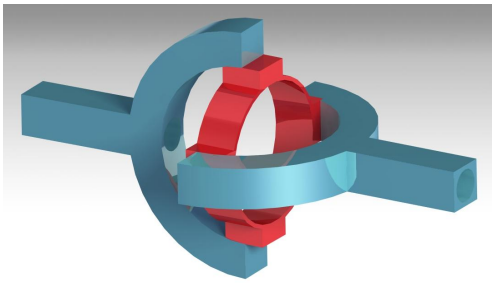


Fig. 3 & 4

In this configuration, two separate designs have been made (illustrated in figure 3 and 4). The first design consists of two above-mentioned hinge configuration with one on the same plane while the other rotated 90 degrees along the axis i.e the body part. The second design is a modified universal joint to allow the user's body part to pass through them. Both designs have a ratchet wheel at the joint and pawl with ring and wires attached to translate the intended movement to the pawl.

These configurations are designed to be integrated into the exoskeleton at certain positions that have been depicted in figure 5 below (1 - Hinge, 2 - Universal and 3 - Rotary).

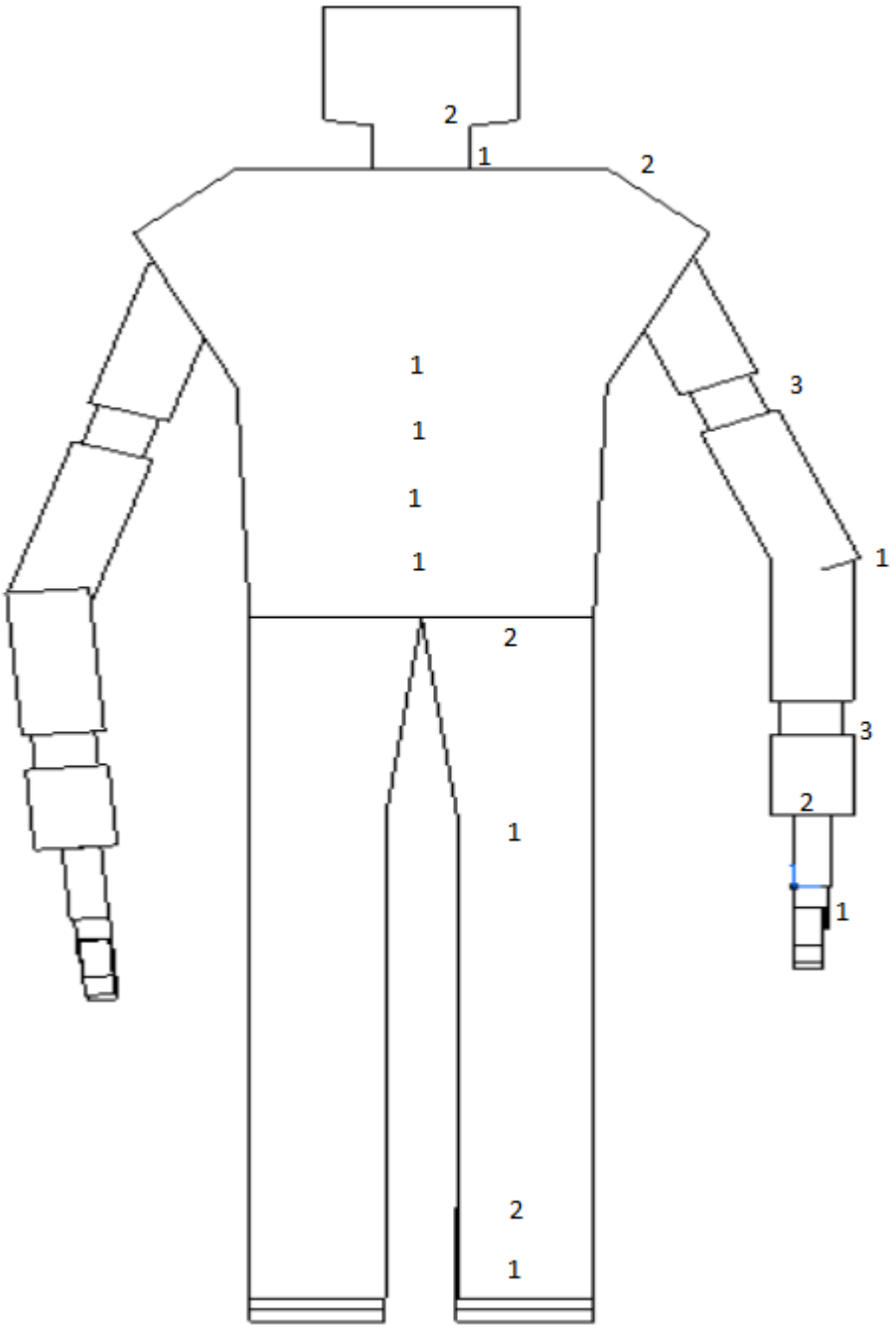


Fig. 5

Hinge configuration have been used around joints such as finger, elbow, knee, neck (lower), shoulder (in first design of universal configuration), knuckles, stomach/back. Likewise rotary configuration has been used between joints such as between wrist and elbow, between elbow and shoulder, between hip and knee and between knee and ankle. The universal configuration has been designed for allowing more degree of freedom than the other two or the combination of both, such as when required on the upper neck joint, has been used around joints such as wrist, shoulder, neck (upper), hip and ankle.The encasings can also be designed with 45 degree extrusion from front and behind if necessary for maximum covering or extra parts can be implemented to cover.

Conclusion

This goal demands a set of non-totalitarian mechanisms for complex types of joints of the human body and has been simplified to 3 allowing further innovations and scope to mechatronics systems to be built onto it. As a downside, the system has a backlash and a delay between movement of the enclosed body part and the mechanism's movement (the space between rings and encasings) while allowing the individual to loosen grip to a certain extent as all other exoskeleton systems. Cables must have a stretch (to an extent) and must come to the joint between both encasings as it the distance from the cables to not to be stretched and cause unintentional movement of the pawl. While this kind of mechanical structure has problems such as high cost of manufacturing and very limited use on its own in the present industrial world, it also offers an innovative design over centuries old mechanical structures while still having scope to be developed into full body exosuit.

Acknowledgments
Dassault Systemes Catia V5 have been used to design the figures in this paper by the main researcher.

References

[1]. US38914A patent, United States.

[2]. Gabriel, Richard A.; Metz, Karen S. (1991). From Sumer to Rome: The Military Capabilities of Ancient Armies. ABC-CLIO. ISBN 978-0-313-27645-3.

[3]. Gabriel, Richard A. (2007). The Ancient World. Greenwood Publishing Group. ISBN 978-0-313-33348-4.

[4]. “Western Civilization” as seen from the Celtic West, Michael Newton, lecture delivered to the St Francis Xavier University Humanities Colloquium.