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Gesture controlled X-RHex (2.0) robot

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ABSTRACT

In this paper, the authors describe the design of Gesture controlled X-RHex (2.0) Robot. X-RHex (2.0) has only six actuators, one motor located at each hip, achieving mechanical simplicity that promotes reliable and robust operation in real-world tasks. The paper is also about improving controlling the robot and accurate handling. Gesture controlling is the solution for easy handling and giving the desired direction to robot effectively. Empirically stable and highly maneuverable locomotion arises from a very simple clock-driven, open loop tripod gait. The main area of paper is to operate the wireless X-RHex (2.0) Robot more efficiently by using an accelerometer sensor.

Keywords— *Gesture controlled robot, Hex legged robot, Accelerometer robot*

1. INTRODUCTION

Nowadays, with the development of technology, several robots with very special integrated systems are particularly employed for such risky jobs to do the work diligently and precisely. Gesture recognition technology has been considered to be the highly successful technology as it saves time to unlock any device. Gesture recognition can be conducted with techniques from computer vision and image processing.

As in today's world, everywhere we are coming in contact with an enormous number of autonomous systems. But, what about the military forces? They are continuously risking their lives to go in the enemy's territory and record their activities. For making them advance, they require new technology. So here comes the first idea of Gesture control robot with X-RHex (1.0).

2. METHODS

The Gesture Controlled X-RHex (1.0) Robot is developed by

2.1 Gesture Controlling

For gesture controlled robot we first developed a mini robot for the sole purpose of testing. The block diagram is given in Figure 3 in the appendix. In this, we have used the HC-05 Bluetooth module to communicate between android accelerometer sensor and Microcontroller.

2.2 X-RHex (1.0) Robot

The robot's design consists of a rigid body with six compliant legs; each possessing only one independently actuated revolute degree of freedom. The attachment points of the legs, as well as the joint orientations, are all fixed relative to the body. X-RHex (1.0) achieves fast and robust forward locomotion traveling at speeds up to one body length per second and traversing height variations well exceeding its body clearance.

Motor Specifications for X-RHex (1.0)
Motor Name – Nema-17 10kgcm
Stall torque – 1Nm
By using 6 motors – 6Nm
Payable capacity – 80N = 8kg

2.3 X-RHex (2.0) Robot

We had a lot of pitfalls about our *X-RHex (1.0) Robot* just like, low payload capacity, less stability, less torque, etc. Also in the market, Kevin C. Galloway and his team designed X-Rhex[18] which is having less efficiency right now. That's why we decided to modify our robot with more powerful aspects such as motors, gearbox, ALU, etc. So here comes the first look of **X-RHex (2.0).**

Table 1: Motor Comparison

Attribute	X-RHex Motor	X-RHex (2.0) Motor
Type	Brushless	Brushless
Maxon part number	251601	339285
Battery Voltage (V)	37	18
No load speed (rpm)	10314	6720
Continuously Sustainable Torque (mNm)	83.1	97.1
Width (mm)	45	45
Length (mm)	20.9	20.9
Mass (mm)	110	110

Table 2: Gearbox head comparison

Attribute	X-RHex Motor	X-RHex (2.0) Motor
Gearbox Type	Planetary	Spur
Maxon gearbox part number	326662	266595
Gear reduction	28:1	32:1
Peak permissible torque	6	6
No load output speed (rpm)	358.39	216.77
Continuous output torque	2.3268	3.1072
Gearbox mass (g)	178	178
Combine mass (g)	288	288

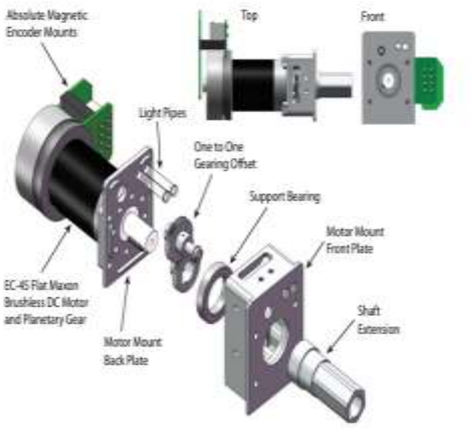

Fig. 1: Exploded view of the motor mounting assembly

3. RESULTS

As a functional prototype, results are quite satisfactory up till now.

Steering

The legs rotate Robot is steered very comfortably. Steering can be connected to any Android device easily

Crossing the obstacles

The legs rotate full circle, thereby preventing the common problem of toe-stubbing in the protraction (swing) phase.

3.1 Calculations

3.1.1 Speed Calculations

Required Speed: 0.5 ft/s: 0.15 m/s
For SCOT legs
Distance covered in 1 revolution
Length of arc = 2*pi*r*(C/360)
Where, r = 0.0785m
And C = Angle subtended by sector = 60°
Hence,
Length of arc = 0.15m
Required speed = 2 rps = 120 rpm (Slow Motion)
For fast retraction = 240rpm
According to motor and gearbox assembly,
N1 = Motor input speed
N2 = Gearbox output speed
i = 32:1
Hence,
N2 = N1/i
N2 = 6720/32
N2 = 216.77 rpm (nearly equals to required speed)

3.1.2 Torque calculations

N1/N2 = T2/T1 = i
T2 = Gearbox output torque
T1 = Gearbox input torque = Motor output torque
T2 = T1*32
T2 = 0.0971*32
T2 = 3.1072 Nm
Combined Total Torque (T) = 18.6432 Nm

3.1.3 Payload Capacity (M)

m = weighable weight.
T = m*r
m = T/r
m = 18.6432/0.0785
m = 237.493 N = 24.21 kg
Subtracting bot overall weight,
M = 24.21 – 0.288*6 – 7
M = 15.48 kg

3.2 Battery power

One major challenge in designing highly mobile platforms is to select a battery solution that is capable of providing enough power at high discharge rates and still has enough capacity to maintain operation for long periods of time without any interruption. X-RHex (2.0) uses lithium polymer (LiPo) batteries. LiPo batteries were chosen because of their high energy-to-weight and energy-to-cost ratios and charge-discharge efficiency [2, 3]. One major advantage of this battery type is the flexibility in form factor. Cells can be built in different shapes and sizes, with battery packs composed of several cells connected in series. Thus, manufacturers have significant control over the final shape of the whole pack. Indeed, as a popular option in RC model airplane and car design, there are LiPo batteries available in a wide variety of capacities, voltage levels, and shapes.

Based on our design specifications, the battery chosen for X-RHex (2.0) is a **TP3500-5SHV**[17]

Specifications

19V High Voltage Series
Capacity: 3500mAh
Cells: 5 (4.35v per cell)
Max Charge: 2C
Max Cont. Discharge: 6A
Max Charge Current: 7A
Max Burst Discharge: 10A
Max Burst Current: 35A
Weight (g) *estimate only*: 330
Max Cont. Current: 21A
Dimensions (mm) *estimate only*: 46x35x110

3.3 Payloads and applications

Development of advanced sensor-based behaviors on a portable, highly-dynamic legged robot is a primary goal of the X-RHex (2.0) project. While essential sensors (motor and battery feedback sensors) have been designed into the body of the robot, the choice of additional sensors largely depends upon robot activity, yet the specifications of the desired sensor package may vary with changing research needs and advancing sensor technologies. To address this issue, we introduce a modular payload architecture that allows X-RHex (2.0) to perform as a *laboratory on legs*; a user may easily change payloads to rapidly develop behaviors in natural, outdoor environments as easily as on a lab bench. To better understand the properties of the robot's dynamic locomotion as well as its external environment. X-RHex (2.0) has been tested to navigate basic terrain successfully with up to 15 kg of payload Weight (Approx.) — more than enough for any planned computational or sensory payload.

3.4 Applications
The modular payload system permits researchers to switch, with minimal downtime, between distinct experiments that use the same mobile platform. Here we describe several existing applications, as well as future application scenarios we envision.

Significant effort has been applied to evaluating RHex-like robots' gaits for the purpose of improving locomotion efficiency. X-RHex is capable of automated gait tuning using a variety of exteroceptive feedback modalities. A critical challenge for automated tuning is the localization of the robot within its environment while evaluating the electrical power consumed [8]. Previous work has utilized an onboard camera to track features in a structured environment [9], an extremely accurate indoor commercial motion capture system [10], and, most recently (with the X-RHex robot), a GPS payload in unstructured outdoor environments. Each tracking method offers advantages and disadvantages, and the modular payload system allows X-RHex to perform gait tuning in a wide range of scenarios.

There is an ongoing effort to develop accurate state estimation for RHex using proprioceptive and vestibular sensors, such as an IMU or leg encoders ([11, 12] among others). Tasks such as performing automated gait adjustments [13, 18], choosing gaits based upon changing surface properties [15], or recovering from a fault such as a broken leg [16] are all intended uses of an improved state estimation capability. X-RHex's (2.0) payload system is primarily geared toward exteroceptive sensing, which we believe can augment and expand the current work in state estimation. As an example of some potential applications, onboard cameras, along with the additional computational power of a payload computer, can be used for measuring optical flow or performing stereo vision, both of which are useful to estimate the robot's motion within an environment.

3.5 Comparison with prior RHex robots
In this section we compare X-RHex (2.0) with prior RHex-like robots, with a focus on Research RHex [1], but also considering Rugged RHex [4, 5, 6] and EduBot [7, 10]. Each of these platforms was developed through multiple iterations—differences between these versions account for the range of values presented for certain parameters. This section is not intended to demonstrate the superiority of any one platform; instead, we aim to highlight the similarities and differences between platforms.

Table 3: Comparison of physical properties

Attribute	Rugged R-Hex	EduBot	X-RHex	X-Rhex (2.0)
Body Height (cm)	14.8	6.3-10.1	7.5	6.2
Overall width (cm)	46.5	34	39	34
Body length (cm)	62.3	36	57	54
Leg to leg spacing (cm)	23.5	15.5	22	20
Ground clearance (cm)	10.6	7-9	12.5	11
Leg diameter (cm)	19.5	10.8-11.7	17.5	15.7
Total weight (kg)	15	2.5-3.6	8.6-9.5	7

4. DISCUSSION
The Gesture controlled X-RHex (2.0) robot is currently operating with Bluetooth Module. Bluetooth module has a limited range but this can be substituted by the RF (Radio Frequency) module, as it has better ranging option. The weight carrying capacity is very low at this stage which can be improved with improved strength of legs of the robot.

5. CONCLUSION
In conclusion of this paper, the author would like to say that any territory can be surveyed with help of such a robot and can be easily handled with gestures.

6. ACKNOWLEDGMENTS
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APPENDIX

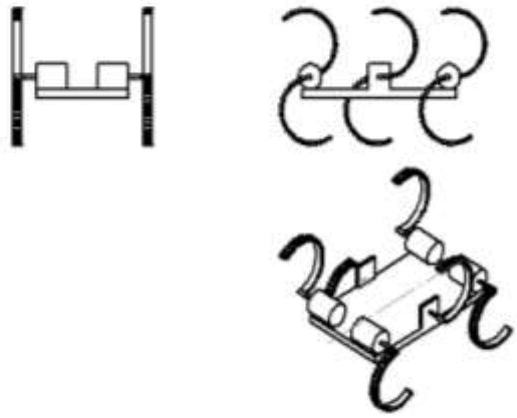

Fig. 2: Assembly drawing

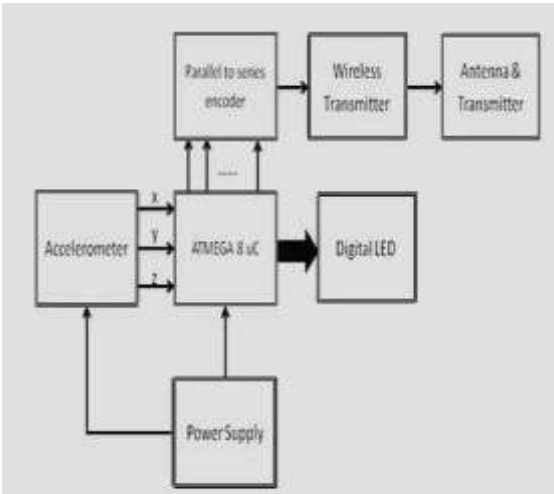

Fig. 3: Block diagram of gesture control