Linkage Design and Optimisation of a Hexapod Walking Robot Used For Surveillance

Jaya Christiyan K G, Nikhil G N

Abstract: The technological advancements at the global level have put in a large demand for walking robots in various industrial and domestic applications. The aim of the paper is to develop a Hexapod (robot with six legs) walking robot that is capable of performing basic movement, such as walking forward and backward, carry payloads and used as a surveillance device. A novel robot leg design has been created with Autodesk Fusion 360, linkage mechanisms of the robot leg is determined by using Linkage 2.0 software. Stress and displacement analysis was done in Autodesk fusion360 software in order to determine whether it can hold the self-weight of the robot and the desired payload to carry the surveillance purpose (i.e. medicine, water, blood etc.). Considering all the possibilities final optimized Hexapod robot design is created using Autodesk Fusion 360 software. Mainly, the undertaken design outline takes into account the fundamental features, such as basic structure, motion planning, payload and walking gait. Fabrication of Hexapod robot parts was completed using additive manufacturing technology FDM process.

Keywords: Autodesk Fusion 360, Linkage2.0, Hexapod robot, FDM, Additive Manufacturing.

I. INTRODUCTION

A hexapod robot basically has six legs. Any robot will be statically stable on three or more legs; a six legged robot has a great deal of flexibility in terms of its movements. Robot can move even one or more legs become disable [1]. Hexapod robots are most statically stable and possess a great flexibility while moving due to its movement or standing straight using six legs. Hexapod robots are inspired from the behavior of the insects with six legs [2]. Nowadays movable robots are becoming much essential, as a desperate need of robots in the field of exploration and surveillance in unknown terrain and normal environment [3]. This process involved in designing and developing the hexapod robot body and legs with two degrees of freedom. Nowadays the use of robots has been increasing rapidly in automobiles and process industries, aviation sectors and even in domestic purposes [4].

By definition hexapod robot have six legs which is inspired by insects such as ants and crickets. The six legs give the hexapod robot the ability to move flexibly across different terrain and does not require any balancing mechanisms to stand straight [5]. These robots play a crucial job in arctic and Antarctic investigations, search and rescue activities and reconnaissance tasks [6]. Hexapod robots might be utilized to test organic speculations about crawly motion of the insects, motor control, and neurobiology [7]. Not at all like industry arm robots which are multi-input multi-yield framework with single end-effector, legged robots are multi-input multi-yield with numerous end-effector frameworks with nonlinear mapping among information and yield [8]. In this way, legged robots are significantly more testing and muddled to structure and control.

The robot legs forward movement is called gait. Regularly, a hexapod robot is constrained by strides, which enable the robot to push ahead, turn, and maybe side step. One significant issue in the advancement of hexapod robots is to think about the movement and create legitimate steps for the robots. For multi-legged robots, major thing to control is by controlling its movement. Each leg must move in such a manner that it efficiently produces thrust and provides maximum support. The motion of all the legs must be coordinated such that they all working together to provide constant stability while moving forward. Each leg has actuators and at any moment in time they are all acting on their individual actions. Hexapod walking robots can have a more industrial use but have some disadvantages which include higher complexity and higher cost, low energy efficiency, and comparatively low speed. Walking robots are very expensive and complex machines, consisting of many actuators, sensors, transmissions and supporting hardware, connecting wires and microcontroller.

The objectives of the proposed work are to design the model of the hexapod robot on Fusion360 Software, stress and strain analysis of the hexapod leg design, fabrication of the robot using additive Manufacturing technology, controlling the robot and testing the hexapod robot.

II. METHODOLOGY

Figure 1 gives the complete working methodology of the manufacturing of Hexapod robot. New design of the Hexapod robot leg consists of four links, the minimum number of DOF required to move a leg is two which moves the leg forward by lifting and swinging. Figure 2 explains the Hexapod leg design; leg mechanism itself has one DOF for lifting, while the base of mechanism has another DOF for swinging.

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The leg design along and the body is modeled with Autodesk Fusion 360 software.

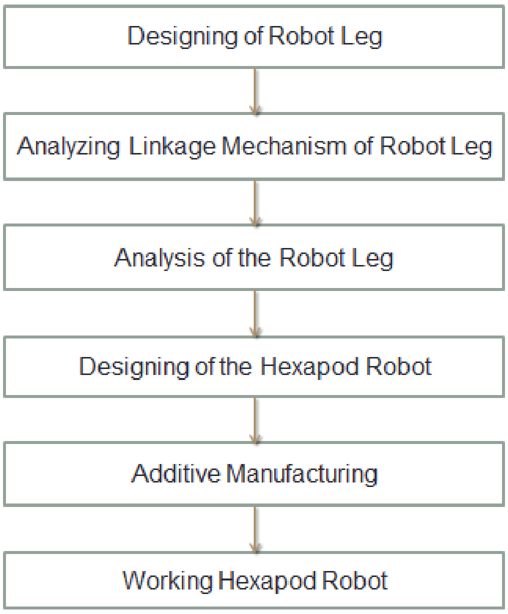

Fig. 1. Block diagram of manufacturing Hexapod robot

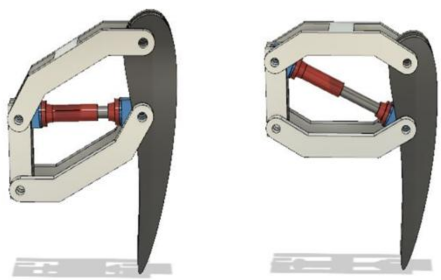

Fig. 2. Robot leg designed in Fusion360 software

The movement of the robot leg is analyzed using Linkage 2.0 software; mechanical linkage is an assembly of bodies connected to manage forces and movement. The movement is studied using geometry of the body or link, so that it is considered to be rigid. Figure 3 explains the mechanisms of the robotic leg in linkage 2.0 software.

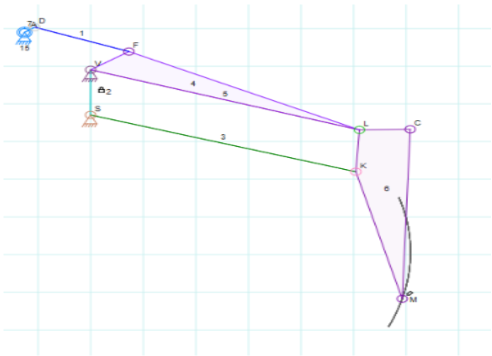

Fig. 3. Mechanism of the robot leg in Linkage2.0 software

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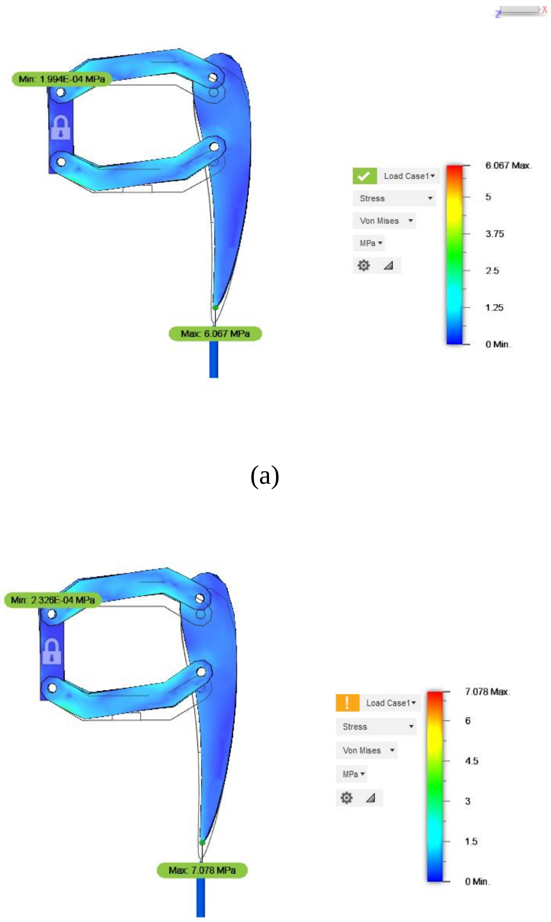


(a)

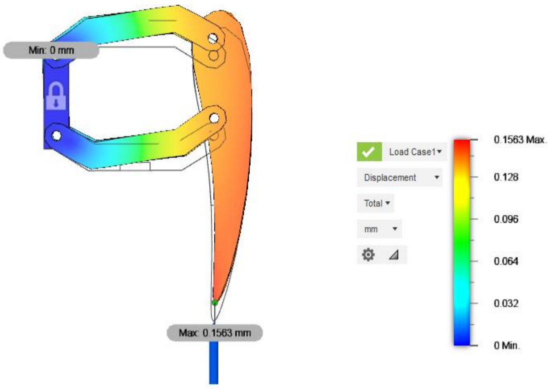
(b)

Figure 4 Stress analysis of the robotic leg in Fusion360 software

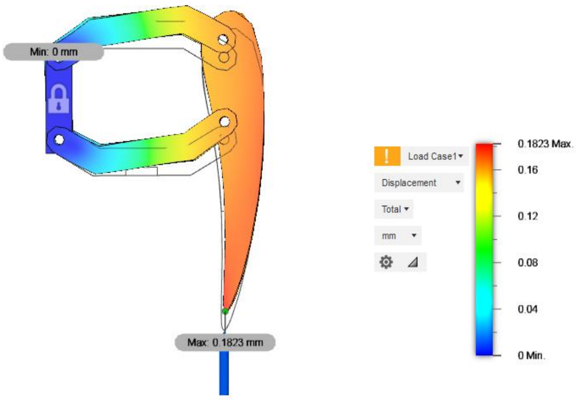
Stress–strain examination (or stress analysis) is a building discipline that utilizations numerous techniques to decide the stresses and strains in materials and structures exposed to certain forces. In continuum mechanics, stress is a physical amount that communicates the interior forces that neighboring material applies on one another, while strain is the proportion of the twisting of the material.

Stress analysis of the robotic leg is shown in figure 4, when a load of 14.715 N or 1.5 kg is applied on the robotic leg which is shown in figure 4(a), Stress is maximum at the bottom of the leg with 6.067 MPa where the design is not expected to bend or brake

But when a load of 17.1675N or 1.75 kg is applied on the robotic leg as shown in figure 4(b) stress is maximum with 7.078 Mpa where the outside factors could cause it to bend of brake that means the design is not safe for weights more than 14.715 N or 1.5 Kg on one leg. Once the robot starts moving out of six legs three legs will always touch the surface. Based on the stress analysis this robot design can sustain a weight of 44.145 N or 4.5 kg of self-weight.



(a)



(b)

Figure 5 Strain analysis of the robotic leg in Fusion360 software

Strain or displacement analysis of the robotic leg is shown in Figure 5, when a load of 14.715N or 1.5kg is applied on the robotic leg as shown in figure 5(a) maximum displacement is found to be 0.1563mm, where the design is not expected to bend or brake. Figure 5(b) gives the strain analysis of the leg design where displacement is found to be 0.1823mm where the outside factors could cause it to bend or brake

Subsequent to choosing the best case structure we moved to the product drawing of hexapod. We needed to know the component of each piece of robot for that. Fusion360software programming via Autodesk was utilized for the plan. Fusin360 is user friendly. It gives genuine pictures, detail representations and ventures for exhibiting structure. It likewise supports surface demonstrating. It gives remarkable drafting operation which can be helpful with details while genuine prototyping. It also provides simulation, animation, weight estimation after adding materials to body, which includes both metal and non-metal. Using the material selection ABS Plastic was chosen to build the robot body because its light weight and have better material strength as it is manufactured by additive manufacturing process.

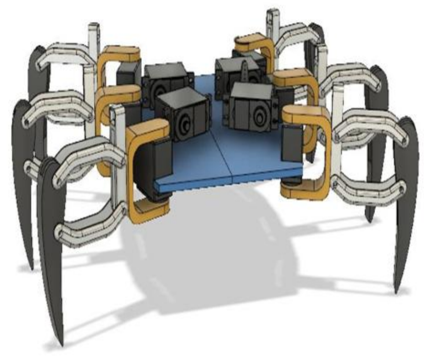


Figure 6 Final design of the Hexapod robot design

Steps involved in FUSION360 design as follows

1. Part modeling of the robot in FUSION360 starting with leg. (Using the element of symmetry helps in design)
2. Assembling all the parts in FUSION360.
3. Defining the joints and contacts of the robot.
4. Drafting of the novel design

III. Additive Manufacturing Technologies

Additive Manufacturing (AM) also known as Rapid prototyping is a technology which creates objects by adding layer by layers' materials such as plastics or metals. It takes advantage of the computer where the design is carried out in software that is 3D modeling software (Computer Aided Design or CAD), machine equipment and layering material. Once a CAD sketch is completed, the AM equipment reads in data from the CAD file and adds successive layers of liquid, powder, sheet material or other, in a layer-upon-layer fashion to fabricate a 3D object which is known as fluid deposition modeling (FDM) process. Robot leg parts are manufactured using additive manufacturing technology, where designs of the leg parts are designed using Fusion360 software

IV. CONCLUSION

This project is influenced by the need for mobile machining systems to avoid humans from hazardous and dangerous environments, search and rescue operations and surveillance operations. A 3D virtual design of the robot system has been created in FUSION360 software. Mechanism of the robot leg is analyzed using linkage 2.0 software. Stress and displacement analysis of robotic leg is to determine if it can sustain the weight of the body is done using Fusion 360 software. As a result of stress and displacement analysis the robotic leg design can sustain the body weight of 44.145N or 4.5kg. Robotic body is build using additive manufacturing technique A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions.

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AUTHORS PROFILE

Dr. Jaya Christiyan. K. G. Completed his B.E degree in Mechanical Engineering from Manonmaniam Sundaranar University, Tirunelveli in 2000. Later he worked as Production Engineer for a period of one year. In 2001 he joined for M.E in Computer Aided Design from Madras University, Chennai. For his M.E Project work he worked in GTRE/DRDO Bangalore and successfully completed a project titled "Various Techniques used to predict the Burst Speed of Turbine Disc". After he joined as CAD/CAM Engineer in Eco Pulp products India (Pvt) Ltd, Hosur for the period of 4 years. From 2006 to 2007 he was worked as Lecturer in P.E.S. School of Engineering, Bangalore. Later he joined M S Ramaiah Institute of Technology as Assistant Professor. He worked as a Faculty Lead and participated for the SAE (Society of Automotive Engineers – 2008-2009) Design and Fabrication of Race CAR (Formula car-A event) to be held at Australia, 26th -30th November 2008.

From 2011 onwards he is actively participated various activity on Additive Manufacturing, as a part of his Doctoral research work in CSIR- National Aerospace Laboratories. He completed in PhD degree in 2017 under Visvesvaraya Technological University. He visited Singapore and Malaysia for paper presentation.

Dr. Christiyan, has a vast experience of 5 years in Industry and 13 Years in academics. He has guided 14 M. Tech students and he published 10 paper in various Scientific Journal and presented 25 papers in various scientific works in National and International conference/workshops. He is also actively involved in carryout several R&D projects sponsored by Institution of Engineers (India), and Karnataka State Council for Science and Technology.

Nikhil. G. N Studying M. Tech (CIM) in Ramaiah Institute of Technology. He Completed BE (Mechanical engineering) in The National Institute of Engineering Mysore. His Final year project in BE was “Design and Development of Low Cost Electronic Governor for BL120H Diesel Engine”. The Main intention of this project was to replace mechanical governor with low cost electronic governor for BL120H Diesel Engine which is mainly used in mining & construction vehicles and defense vehicles in military applications. This project was considered under make in India project under the guidance of BEML Mysore. He did he internship in ACE designers for a period of 2 months.