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3D PRINTED PROSTHETICS FOR DOG

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Abstract —
A lot of Dogs and Dog owners suffer physically and mentally if pets lose their legs in any accident. In this project we have designed a prosthetic limb for such cases where the Dog has lost its front limb. Prosthetic limbs are life preserving application that offer amputees a path to use lost limbs. But now-a-days, technology has developed to the point that any material can be printed by using 3D printing technology. This paper aims to provide information on the majority of existing 3D printed materials and to investigate their potential to build the prosthetic limb using 3D printed technology. In this project materials such as PEEK, Aluminium , Stainless steel etc are used. Here we have implemented the concept of modularity i.e. the parts such as the lower paw and the adjustable rods can be easily separated and replaced if damaged. We have also tried to 3D print a prototype of our actual model.

Keywords —
prosthetic limb, 3D printing technology, PEEK, Aluminium , Stainless steel , modularity , prototype

I. INTRODUCTION

At early times, man-made devices which manufactured for the purpose of injured animals were very costly and time consuming. So 3D printing changes the calculations by making it easier. And thanks to 3D printing for making prosthetics for injured animals by using the different 3D printing technologies.
Our paper mainly focuses on the use of prosthetics for injured dogs and how they are going to be manufactured. By improving the capabilities of 3D printing technologies, to make prosthetics more comfortable and durable.

Animals who lost their body parts/limbs in an accident or due to some injury, these animals are starting to gain some medical treatment and biological care, by using the prosthetic limbs and hence, the personalized prostheses, braces(knee brace, back brace), straps allow these animals to live longer & better life.
When we are relating to dogs with prosthetics, we found multiple dog's species as well as the extreme size variation among the dogs, so for solving this issue, materials and 3D printing processes also plays an important role with correct dimensions. Our project mainly refers to 2 types of 3D printing technologies: SLA(Stereolithography) & FDM(Fused Deposition Modeling)[5] .

II. LITERATURE REVIEW

Md. Shiyad K.K., & V. Malik from Pandit Deen Dayal Upadhayay Vishwavidyalay, Mathura. performed some surgical operations on dogs in which they used the closed coil steel spring from construction of prosthesis. They also used three different steel spring coils with different dimensions that were used for different body weights of the animals.[1]
In the article Influence of Layer Thickness, Raster Angle on the Mechanical Properties of 3D-Printed

PEEK and a Comparative Mechanical Study between PEEK and ABS written by Wenzheng Wu , Di Zhao, Haibo Zhang and Ji Zhao they have given a brief information about the materials used in 3D printing, the printing parameters of polyether-ether-ketone (PEEK) 3D printing, Mechanical properties of PEEK and acrylonitrile butadiene styrene (ABS), Mechanical properties in different layer thickness and different raster angles, Comparison of ABS and PEEK Tensile Strengths, compressive strength etc.[2] Susan Aikman, Ally Meile refers to the additive manufacturing process used as 3D printing with Ultimaker 2 & Ultimaker 2+ extended printers. PLA (Polylactic Acid) filament is used for prosthetics To print the bottom loop and to wrap the brace around the thigh was made by the cheetah filament as it has flexibility & printing capabilities. [3]

III. METHODOLOGY

A. Problem Statement

There are many existing prosthetic leg models for dogs in the market. But the major problem faced by their users is that the paw or the lower part of the prosthetic which comes in contact with the ground wears or if there is any damage caused to the prosthetic the user has to replace the whole assembly. In our project we are applying the idea of modularity. Here the user will be able to separate the parts of the prosthetic leg and can only replace the damaged part. Also, we have designed different types of grips for different surfaces. And the height of the leg can also be adjusted according to the height of the dog. The designing of the parts is also simple.

B. Components:

1. Socket :

Fig1: Socket

This part will get attached to the upper limb of the dog with the help of belts which will either be in Y or X shape. These belts will cover the lower neck of the dog which will avoid the movement of the socket. The inner lining of the socket will be covered with a soft sponge like material to prevent any kind skin infection to the dog.[16]

2. Inner and outer adjustable rods:

Fig2: Adjustable rods

There are two rods one is the outer rod and the other is inner rod which will help in adjusting the height of the prosthetic leg. Large holes are given vertically on both the rods throughout to coincide the rods and fix it with nuts and bolts. These large holes are for large adjustments .If any smaller adjustments are required, small holes are provided at the base of the rod.

3. Paw :

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Fig3: Paw

This will be fitted at the end of the rods and will be the part that comes in contact with the ground. The outer layer of the paw that comes in contact with the ground will be given a rubber grip. The shape of the paw is elliptical to provide slight suspension when the dog jumps.

4. Materials:

For the prosthetic designs to function optimally, it needs to be lightweight and strong. An appropriate material is chosen based on the needs and taking physical and mechanical qualities of materials into account. Different materials are used to design each component of the prosthetic.

Actual prosthetic can be printed by using following materials:

Socket of the prosthetic can be made by using PEEK (polyether-ether ketone) material which is a colorless organic thermoplastic polymer. It has high resistance to biodegradation. One of the few plastics which is compatible with ultra -high vacuum applications, this property makes it suitable for medical implants. A flexible inner socket material needs to be lined with soft material for comfortness and easy muscle movement. Polyurethane material is used because it is soft, comfortable and supportive.

Material of the outer and inner rod of the prosthetic will depend upon the weight of the dog. Outer rod of prosthetics can be made of Aluminium alloy which is suitable for designing because of their high strength to weight ratio and its resistance to corrosion. Inner rod can be printed by using stainless steel for high strength or HDPE (High density polyethylene) is a thermoplastic polymer. It has a high strength/density ratio. Its strength and lightness make it suitable for these types of medical needs, and its durability as a material lowers costs and increases accessibility. Also for designing of paw PEEK material can be used.[14]

Prototype of the prosthetic is printed by using following materials:

PLA(polylactic acid) is used to print the socket and paw and ABS(Acrylonitrile Butadiene Styrene)to print the rods of the prosthetic[19]. As compared to other thermoplastics PLA needs low printing temperature, is Biodegradable, easily pigmented and It comes in a diverse range of colors and blends. PLA prints are effortlessly sanded, polished, and painted, allowing for a better surface finish with minimal effort.[15]

Component	Material	Properties
Socket	Polyurethane	-Soft & Flexible -Reduces friction
	PEEK	-Rigid structure -Thermoplastic
Outer Rod	Aluminum alloy	- Strong - Cheap
Inner Rod	Stainless steel	-Heavier and strong -Usually used for small components
Paw	PEEK	-Thermoplastic

Table no.01: Material Prop erties

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D. Dimensions :

1. Socket :

Inner Diameter	Outer Diameter	Total height
44.85 mm	45 mm	146.29 mm

Table no. 02

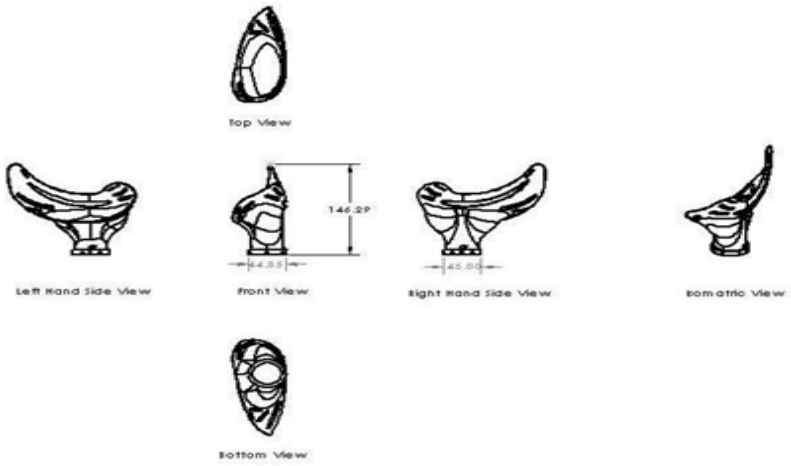

Fig4: Dimensions of Socket

2. Inner and Outer adjustable rods

: Inner rod :

Length	Diameter	Radius of large holes	Radius of small holes
121 mm	31 mm	3.7 mm	1.5 mm

Table no. 03

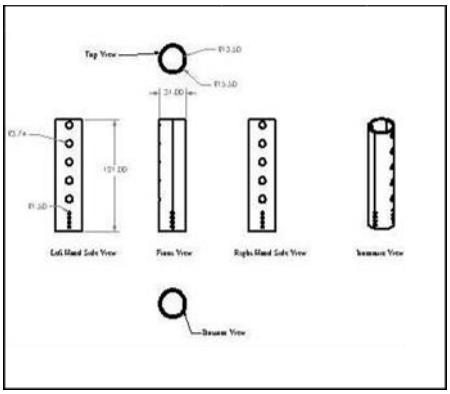

Fig5: Dimensions of Inner Rod

Outer rod :

Length	Diameter	Radius of large hole	Radius of small hole
102 mm	35 mm	3.7 mm	1.5 mm

Table no. 04

Fig6: Dimensions of Outer Rod

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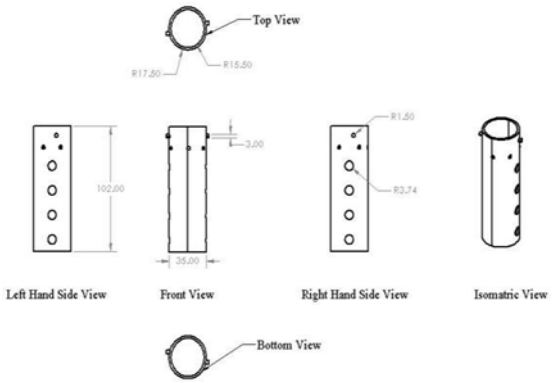
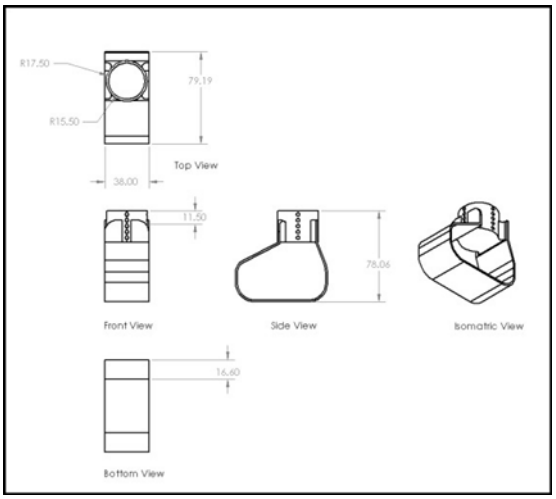


Fig6: Dimensions of Outer Rod

3. Paw (Floor) :

Table no. 05

Length	Breadth
78.06 mm	79.19 mm



E. Designed Model :

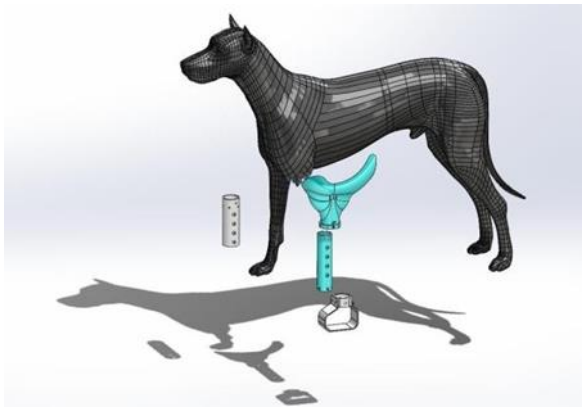


Fig7: Exploded View

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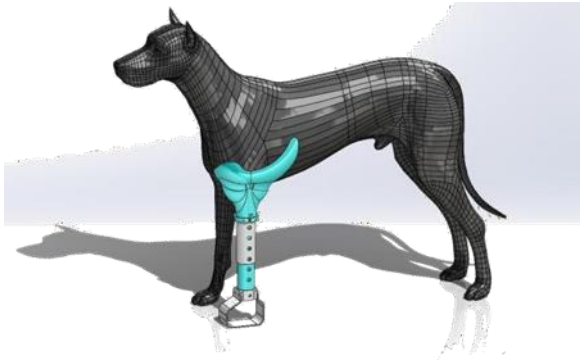

Fig8 :Assembled View

This design mainly focuses on one of the most important guidelines of Design for Manufacturing and Assembly (DFMA) which is modularity.

The CAD model is designed in the Solidworks software. The similar model has been imported from the Grabcad website which is similar to our case.

The socket is connected to the adjustable rods via screws. Further the outer and the inner rods are interconnected through nuts and bolts. This assembly is further joint to the paw nuts and bolts. Multiple paws are designed for various purposes like when the dog is moving, jumping in the outside surrounding the parabolic shaped paw with the rubber grip is used to absorb shocks and sudden load and when the dog is at home the flat surfaced paw is used to provide better surface contact area for friction.

F. Prototyped Model:

Prototyping is a demonstration of user interface and user experience design.It helps us to discover the design problems before we actually manufacture the product. Also it helps us to know the estimation of the cost, manufacturing and material requirement of the product.

To prototype an actual model, miniaturization has been done by changing and optimizing the dimensions for the 3D printer.

Fig9: Prototyped Model

G. Process

After material selection, respective processes are selected to print the prototype. There are mainly two processes applicable for these PLA, ABS, PEEK materials. or the PEEK as well as ABS material mainly used FDM (Fused Deposition Modeling Process)[8] in this process this PEEK filament is used as a raw material. This material is passed through nozzle. In the nozzle these PEEK material are heated by using various types of heaters. After that the melted filament material is printed over the

table of required geometry. After that the post processing operation like as finishing,as well as removing the support structure are performed[18].

For PLA materials most of the cases SLA i.e Stereolithography process has been used. In the SLA process PLA or various types of resin are used as a raw material. Stereolithography belongs to additive manufacturing technologies which is also called vat photopolymerization, commonly known as resin 3D printing[17]. These machines are all built around the same principle, using a light source means probably in this process ultrasonic waves are used as a light source.The laser cures liquid resin into hardened plastic[11].

IV. LIMITATIONS

- No degree of freedom
- The length is not adjustable when the product is in working mode.
- If a dog is weak then the product will act as a liability more than a facility.

V. FUTURE SCOPE

- Similarly,Prosthetic legs also can be printed for other animals like cats, sheep, etc.
- Many other designs of paw can also be developed for various purposes.
- Prosthetic leg for animals will be more personalized and produced on demand,on the basis of aesthetics like color and graphics

VI. CONCLUSION

When it comes to customize the product, 3D Printing is the best method to print the Prosthesis legs. There are several methods which can be used in 3D printing. In this Prototype SLA (Stereolithography) process has been used. And in this Prototype ABS material is used for rods and for Socket and Paw PLA material is used.. And actual prosthesis can be print by PEEK material which has suitable properties for the prosthetic leg..First there is Pre Processing where SolidWorks has been used for preparing a CAD Model And After that The Stl file file Import in Ultimaker Cura Software And Then After Setting Of Orientation And Other Settings. There Is Post Processing And Post curing. In SLA UV Lasers are used to solidify Resin But Some Part Of Resin can not solidify So that's why post curing process used. And in post Processing The Removal Of Support Structure occurred.

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