Armature design for animatronics and stop motion animation

DRS report

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Acknowledgement

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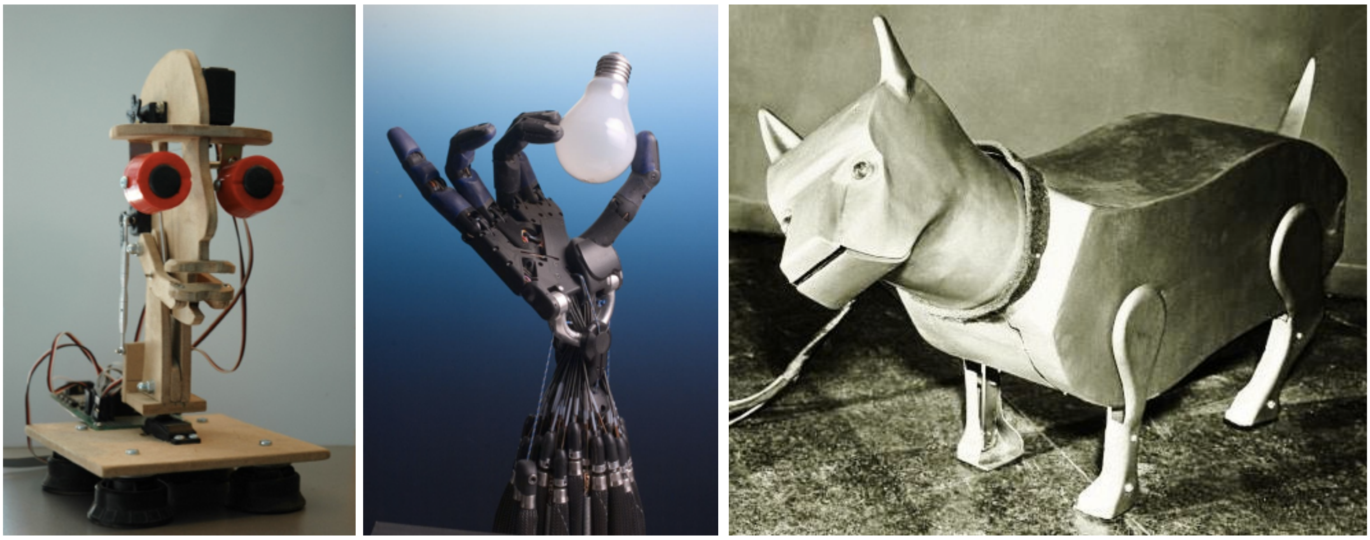
Introduction

Animatronics originates from the words anima and electronics. Anima means- to animate while electronics provides the control parameters to the movements. Animatronics refers to the use of robotic devices to emulate a human or an animal, or bring lifelike characteristics to an otherwise inanimate object. A robot designed to be a convincing imitation of a human is more specifically labeled as an android. Modern animatronics have found widespread applications in movie special effects and theme parks and have, since their inception, been primarily used as a spectacle of amusement.

Animatronics is a multi-disciplinary field which integrates anatomy, robots, mechatronics, and puppetry resulting in lifelike animation. Animatronic figures are often powered by pneumatics, hydraulics, and/or by electrical means, and can be implemented using both computer control and human control, including remote operation. Motion actuators are often used to imitate muscle movements and create realistic motions in limbs. Figures are covered with body shells and flexible skins made of hard and soft plastic materials and finished with details like colors, hair and feathers and other components to make the figure more realistic.



Animatronic structures

Left: Bob the figurehead , By ValterG
Centre: Hand, By Richard Greenhill and Hugo Elias of the Shadow Robot Company
Right: Sparko the Robot Dog-1940, By Paul Gosselin

Stop motion animation

Stop motion animation (also called stop frame animation) is animation that is captured one frame at time, with physical objects that are moved between frames. When you play back the sequence of images rapidly, it creates the illusion of movement.
An understanding of how 2D animation works helps in relating it to stop motion animation. Like in a flip book, where sketches transform or move from one frame to another; in stop motion, physical objects are transformed or moved instead of drawings.

Persistence of vision helps us correlate the various frames into a dynamic effect which make the physical objects appear to move or transform into ways that would not have been possible

The basic process of animation involves taking a photograph of your objects or characters, moving them slightly, and taking another photograph. When you play back the images consecutively, the objects or characters appear to move on their own.

The project deals with the basic steps of animatronics up until the armature design for ease of fabrication, setup, dimensioning and its modularity without getting into the electronics aspect of movements.

Process

The process of Animatronics involves the following steps:

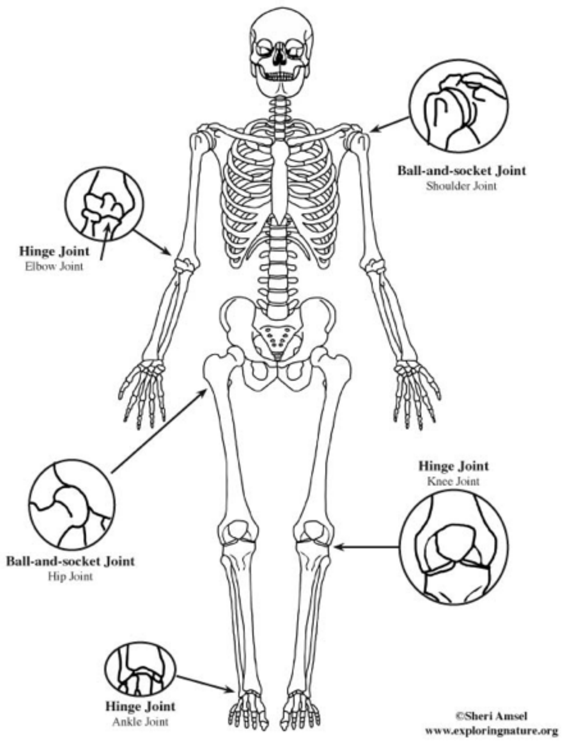
- Drawing
- Maquette (or miniature model)
- Full size sculptures
- Molds and casts
- Animatronic components
- Connections
- Testing

Drawing:

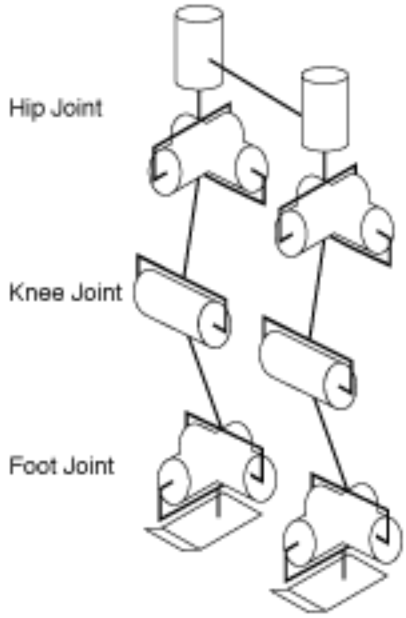
A precise drawing of the anatomical structure is made to understand the length of members and joints in order to furnish a workable plan for full scale deployment. The drawing takes into consideration the various postures and auxiliary equipments which shall be put onto the animatronic structure.

A drawing, though immensely helpful in making fictional characters into animatronic structures, it also helps in defining the dimensions for own characters and animals too.

Study of the human anatomy



Human anatomical joints (Source: exploringnature.org)



Mechanical analogy of joints in legs (Source: Honda asimo robot drawings)

The human anatomy and its numerous mechanical interpretations of joints and members provides the necessary clues for developing the mechanical joints in a DIY fashion

the other consideration in the design was that the joints should be friction fitting, hence allowing the animator to change the movement or form angles and make sure that they arrest in the same position.

Various other considerations were also shared by practising animators that they would need all fixtures and joints to be made beforehand and the screws or fittings be put in place before they provide the outer layering of the armature.

Once casted in silicone or draped with foam, fabric or clay, the joints will no longer remain accessible for changes and would need to perform by affixing the position they are kept in.

Type of joints

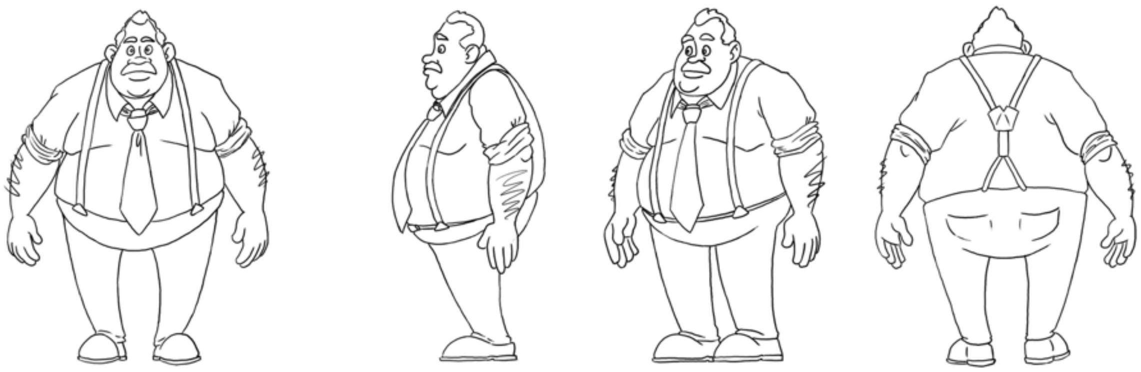
Fig: Various Joints studied to arrive at the most optimal construction style for frugal fabrication. [L to R from top: Friction joint using rubber bands, 3D printed ball and socket joint chain, Wood clamp joystick, 3D printed slotted joint, Antenna joint, Laser cut wood joint with ball assembly, universal joint, Antenna joinery without ball and socket]

It was understood that a universal joint would suffice the much needed modularity and ease of set up in the armature. Ball joints seem to be the best foot forward with intervention required in making a frugal joint from off the shelf repositioned products. Ball joints are chosen as they are versatile and can be made to replicate the motion of any joint irrespective of the character being animated

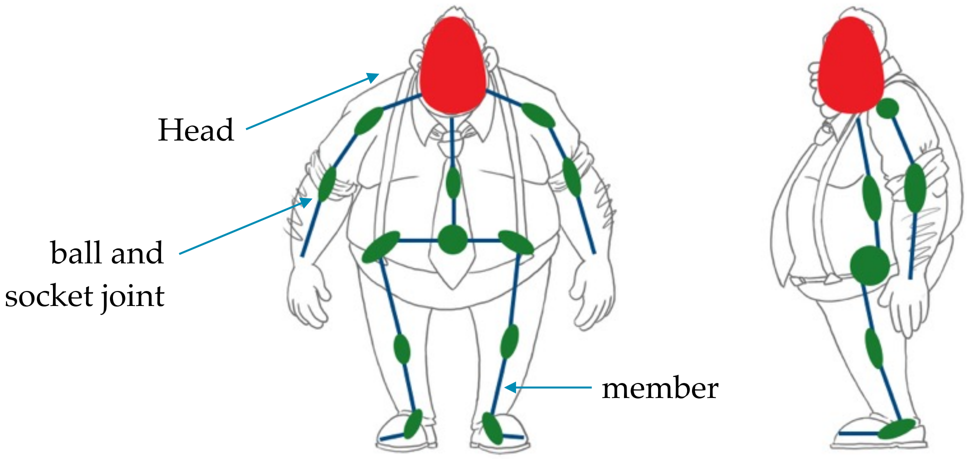
Steps to making armature

1. Using your drawing, measure the length of the areas where the "bones" are going to be on your armature.
    - These are going to be the upper and lower arms, thighs and shins, shoulder/chest area, and pelvis/hip areas.
    - make sure that the effective length of the members would be length minus the length of the ball socket joint available to use
2. Label each length element and place onto your drawing sheet for verification of dimensions
3. Find the type of joints and distance between them in order to replicate the desired motion of your character
4. Arrange the joints and members without affixing onto your drawing
5. Carefully join the members with the ball joints to result in your final armature
6. tweak the tension on the screws to reach the desired flexibility in movement
7. Mount on a stand or base for uses where the character is flying or its anatomy is not supported itself by the weight on the ground.

Example of armature making process



Character sketch of Big joe (Source: Author, courtesy: Amruta)



Best fit anatomy for armature design (Source: Author)

And added layer would be to emulate the waist of the armature by placing a plate or disk in the pelvic region.

Existing armatures

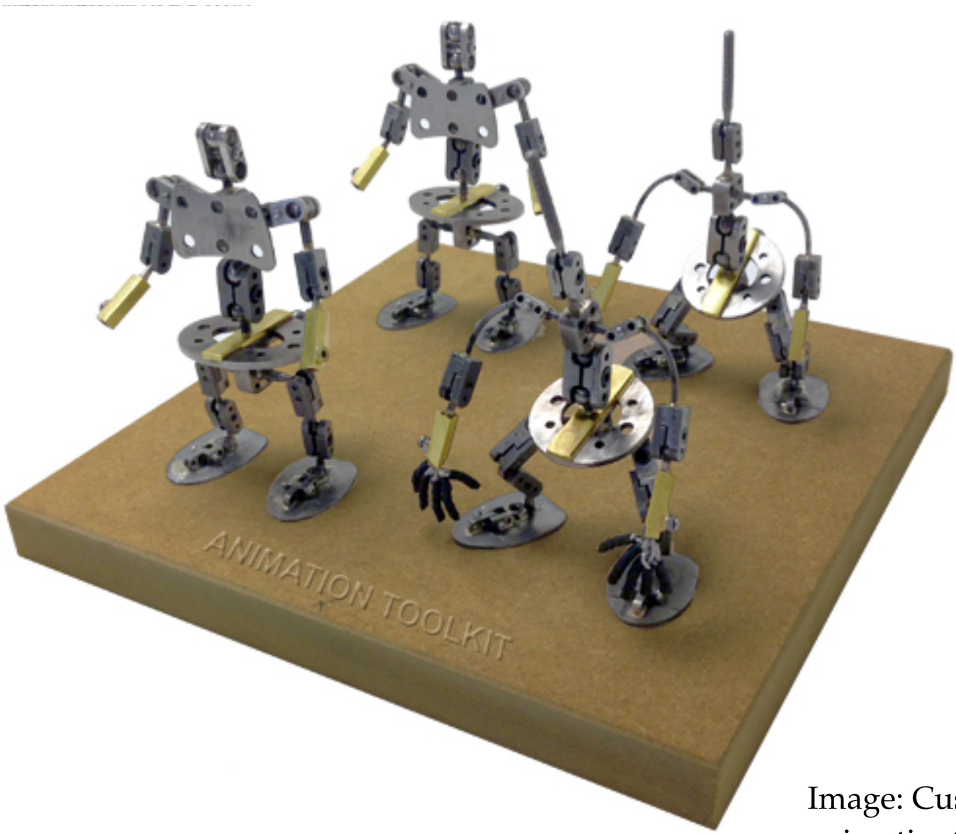


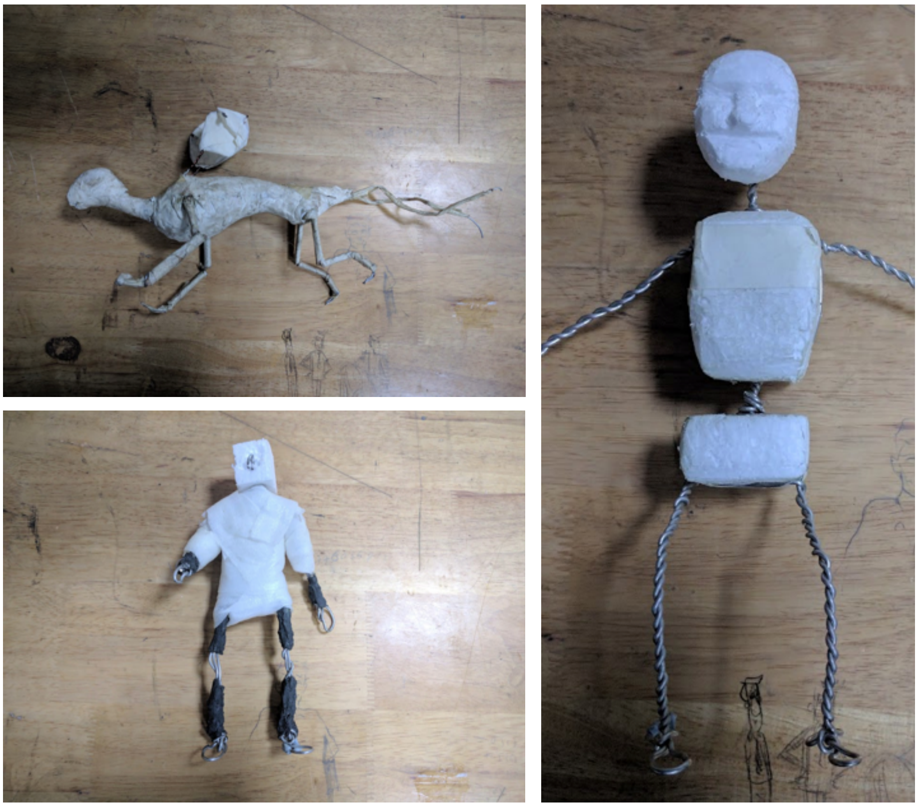
Image: Custom armature design by animationtoolkit.com

Image: standard armature design by Armabenders

Image: standard armature design used for constructing an animal

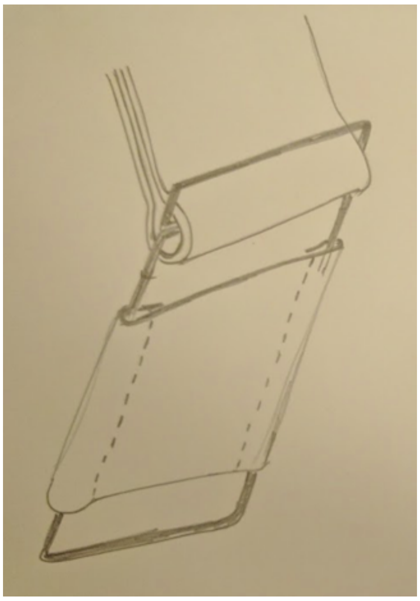
Armatures currently made use of in IDC

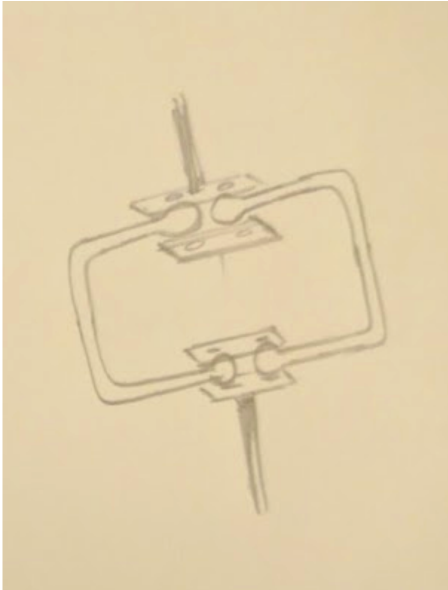
Wooden armature (commonly known as mannequin) with friction joints enabled by springs and slotted spherical wood joinery



Twisted Aluminium wire based armatures often affixed with a hard epoxy based mouldable dough or styrofoam and finished with masking tape and foam to bring the volume
disadvantage: Regular bending causes the wire twists to crack

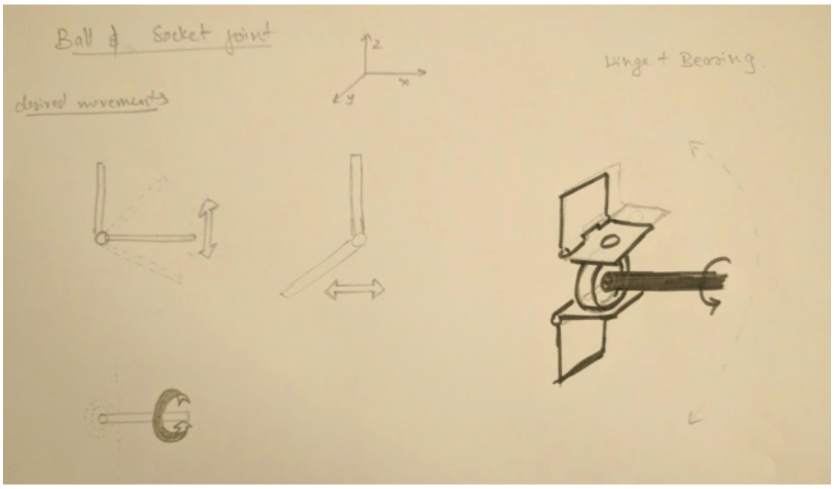
Alternate joinery ideations

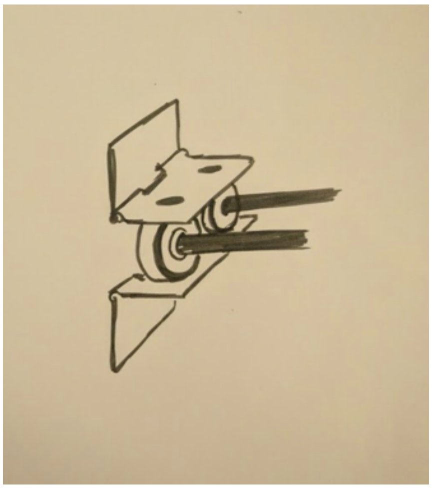




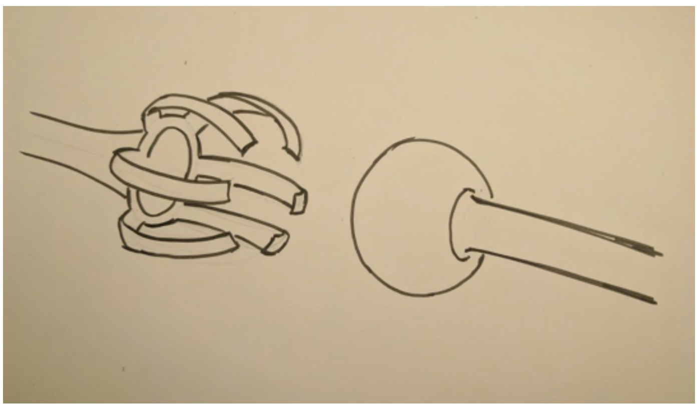
Left: A simple 2D hinge which allows for volumetric addition on the fabric material. Useful for elbow and knee joint

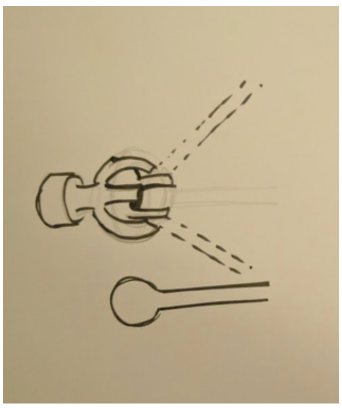
Right: A more detailed joinery detail with two spherical ball and socket in perpendicular axis to replicate a universal joint





Above: A combination of hinge (2D movement) and ball bearing (rotational movement) to replicate the ball and socket joint





Another ball and socket joint ideation but it turned out to be difficult to source off the shelf

Armature design with Thick single core multi thread wires

Exploration using Thick single core multi thread copper wires with wire dis 1.5mm This thickness allows for the requisite rigidity for members as well as the sharp angles required for making the joints. This is more reusable than coiled aluminium wires and can be easily adapted to any shape or character. the limitation being the fixation of intermediary joints with the copper core threads. Even stripping a continuos wire at variable gaps may require additional craftsmanship, hence the ball and socket joint modular structure is preferred

Armature design with ball and socket joint

Final models with spherical rivets used for ball and socket joint with threaded rod members for easy fixing. the base has been mounted to the hip joint
(Image source: author)

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