Mechanical Design and Optimization of an Interactive Animatronic Bald Eagle

Eric Burns
Georgia Southern University, eb02657@georgiasouthern.edu

Mechanical Design and Optimization of an Interactive Animatronic Bald Eagle

Author: **Eric Burns**, ***Advisor:*** **Biswanath Samanta, PhD**

Department of Mechanical Engineering, Georgia Southern University, Statesboro, GA 30460, USA

The Allen E. Paulson College of **Engineering and Information Technology**

Introduction

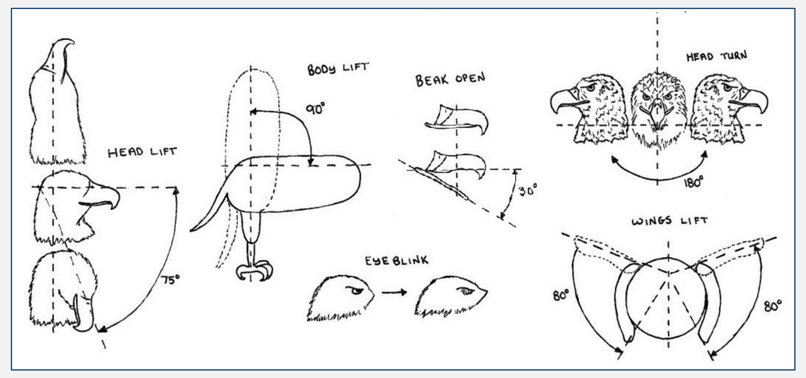
- Animatronics falls under the broad category of mechatronics, which can be construed as the intersection between mechanical and electrical engineering. The idea that mechanical and electrical components can be designed and implemented to simulate animated objects or characters defines the sub-category of animatronics. The hallmark challenge of animatronics is the design and packaging of components and mechanisms that replicate organic kinematics that are both practical for manufacturing and robust for extended duty cycles.

Objectives

- Optimize motions to result in a lifelike Bald Eagle named Opportunity, designed to act in static and mobile applications.
- Develop a complete CAD model to imitate industry-grade work, analyze packaging, and create a test bed for future development.
- Through implementation of passive, interactive, static, and mobile applications, study effects on audience entertainment.

Progression

- The eagle will include 7 essential functions (equal to the number of motors within the design), illustrated in the figure below:

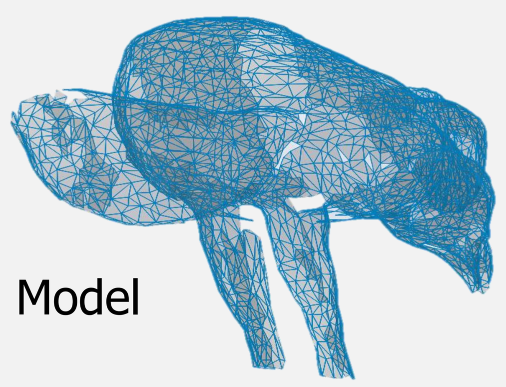


- Following the fabrication of the physical systems, the animatronic will be accomplished over the course of 4 stages, each one slowly increasing in complexity and realism:
- **Stage 1:** Prescript (Spring 2016)
  - Operate based on motor position control and pre-script
- **Stage 2:** Actor-Control (Fall 2016)
  - Utilize controller input to function in real time
- **Stage 3:** Non-Present, Actor-Control (Fall 2016)
  - User input designates motions from an off-site location through Wi-Fi connection and camera
- **Stage 4:** Mobile Actor-Control (TBD)
  - Shoulder support system will allow the animatronic to move from place to place while energy and electrical components are housed in a backpack worn by the actor (Right)

Model Development

- The first step in designing an animatronic is to create the constraints of internal mechanisms. To do so, a clay model of an eagle was developed. This model was then scanned using a *FARO ScanArm.*
- The scanned model could then be used to determine the location of motions and as a size-limiting shell by which internal mechanisms are controlled.

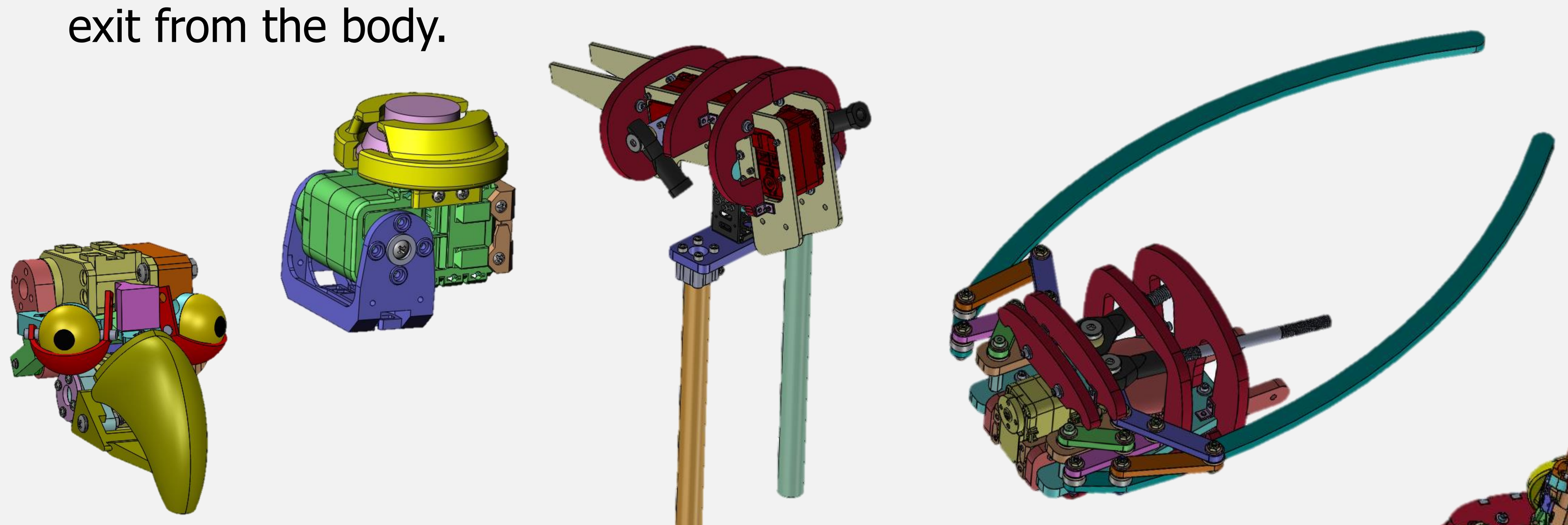
Clay Model



Laser-Scanned Model

Mechanical Design

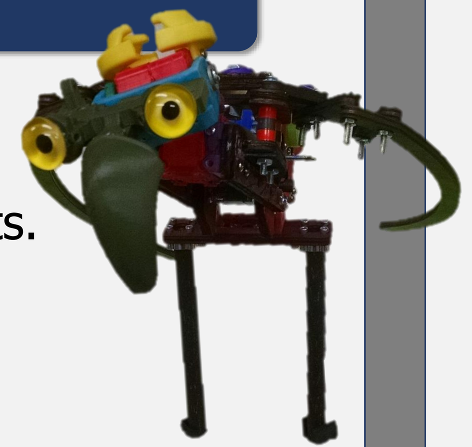
- By utilizing the laser scanned model, the designer knows all limitations and constraints. The internal structures were implemented from the ground up, starting with the leg shafts which must be hollow to allow wires an invisible exit from the body.



- In SolidWorks, separate sub-assemblies were designed to replicate the actual fabrication of the animatronic. This way, it is guaranteed that the design can actually be fabricated; that is, the system is free of impossible connections or movements.
- To allow for skin and feathering to be flush and firm upon touch, the dark red ribs and gray runners were designed, an idea taken from model planes. The skin can be pulled taut around this support structure and simultaneously prevented from contacting any mechanisms.

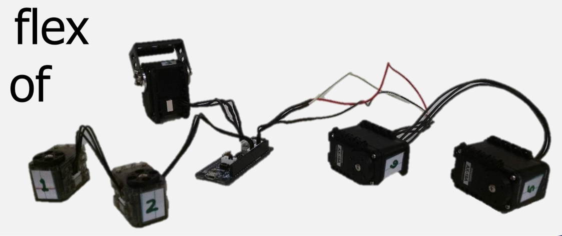
Manufacturing

- Considerations were made to allow easier access to critical components. In addition, modifications were implemented to allow for easier assembly and disassembly of all major components.
- The "Dummy Model" (Right) is a prototype that uses 3D printed parts and laser-cut plywood. In this way, the animatronic is tested inexpensively and any errors can be adjusted for before final fabrication.



Control

- An integral part of the control system lies in the ability of all servomotors to be daisy chained in a single line. This capability significantly decreases wire build-up inside the eagle and, in turn, allows more room for mechanisms.
- While servomotors can be daisy chained, they do not operate based on identical voltages and currents. To adjust, step-down voltage regulators are used.
- For latter stages of the research, Wi-Fi cameras will be mounted onto the perch and flex sensors will be hidden in the gloves of the actor for real-time control.



Quantifying Entertainment

- A similar approach will be used to that which Brian Burns applied with "Kronos," the animatronic dragon.
- Based on the findings of Read and Macfarlane from Child Computer Interaction Group, the most effective way to quantify fun is by way of a simple 1-5 scale, *Smileyometer*.

- During performances, audiences will be asked to note the amount of entertainment they experienced using the 1-5 scale above. Based on the difference in entertainment for similar audiences, it can be determined whether or not the interactive features of Opportunity are more or less effective when compared to the pre-scripted functions.

Outcomes and Next Steps

- Mechanisms perform as desired, with likeness to a real eagle. The design of systems with the intention of relatively simplistic assembly and disassembly was achieved.
- Currently, aesthetics are being designed. Skin is cut from a sheet of neoprene, a synthetic rubber. The skin will wrap around the ribs and runners and then snap together to ensure it can be removed with ease.

Acknowledgements

- I would like to thank Dr. Brian Vlcek for his continuous support, Brian Burns for guidance, my family for their unwavering encouragement, and the Department of Mechanical Engineering at Georgia Southern University for providing all necessary resources.