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Design and Implementation of an Interactive Animatronic System for Guest Response Analysis

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Introduction

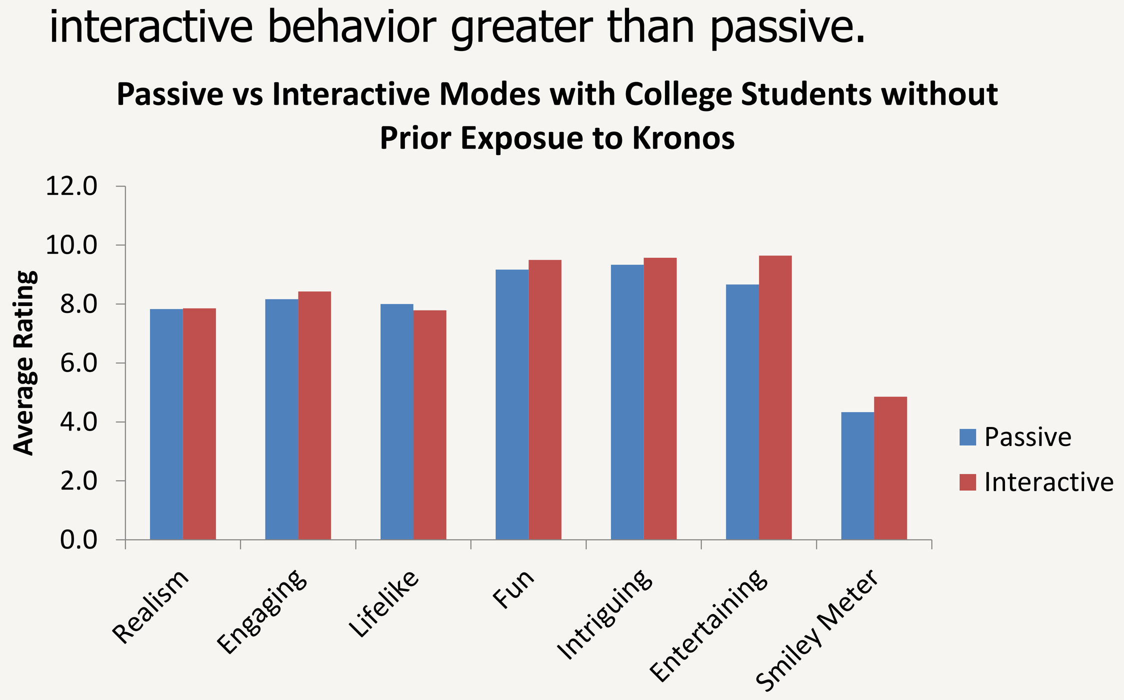
- Within entertainment applications, animatronics must be identified as human partners to establish status for dynamic interactions for enhanced acceptance and effectiveness as socially-interactive agents. This research covers the design and implementation for human identification using a depth camera (Carmine from PrimeSense), an open-source middleware (NITE from OpenNI), Java-based Processing and an Arduino microcontroller into an animatronic dragon. Using the data from depth camera, people are identified by approximating a person's skeletal information. Based on the movements of the individual, the program tracks a human body, or bodies, within the camera's field of view. Joint locations, in the tracked human, are isolated for specific usage by the program. Joints include the head, torso, shoulders, elbows, hands, knees and feet. The dragon capabilities include a four degrees-of-freedom neck, moving wings, tail, jaw, blinking eyes and sound effects. These outputs instigate a movement in the tracked human, which establishes the cycle of human to animatronic interactions. This animatronic creature design will allow for future research in the effectiveness of interactive elements in themed environments.

Hypothesis

- A people-aware, autonomous, animatronic system can be designed for testing effectiveness of interactive animatronics.
- Interactive, animatronic behavior will be more entertaining than passive behavior.

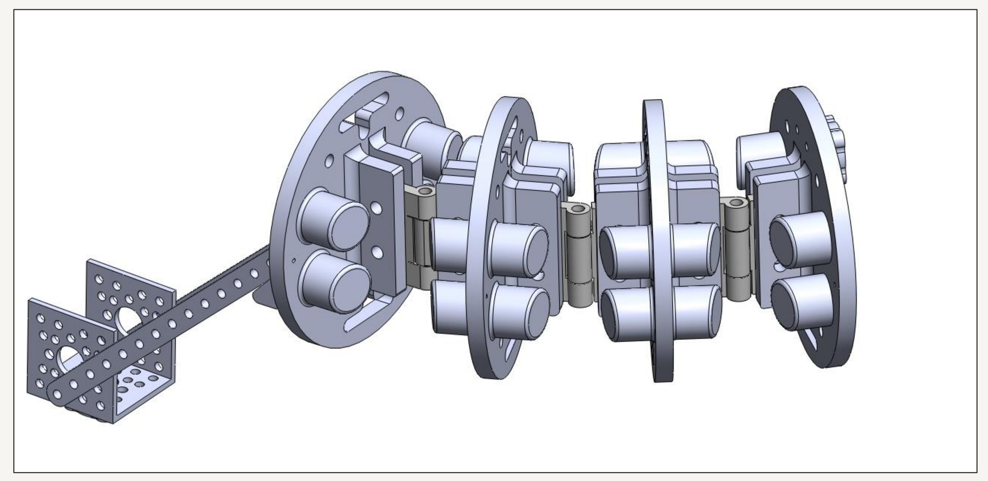
Guest Feedback

- Two small studies have been conducted with elementary school students and college students. No statistical difference was found between passive and interactive behaviors with the children. College students, without prior exposure to Kronos, ranked interactive behavior greater than passive.

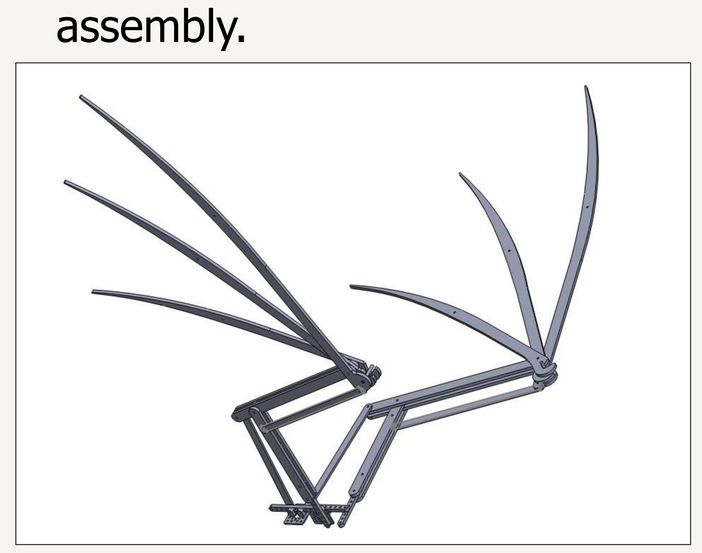


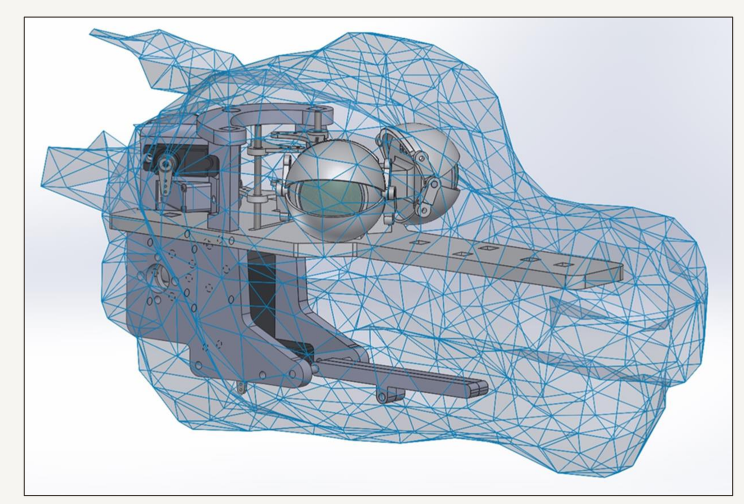
Design and Fabrication

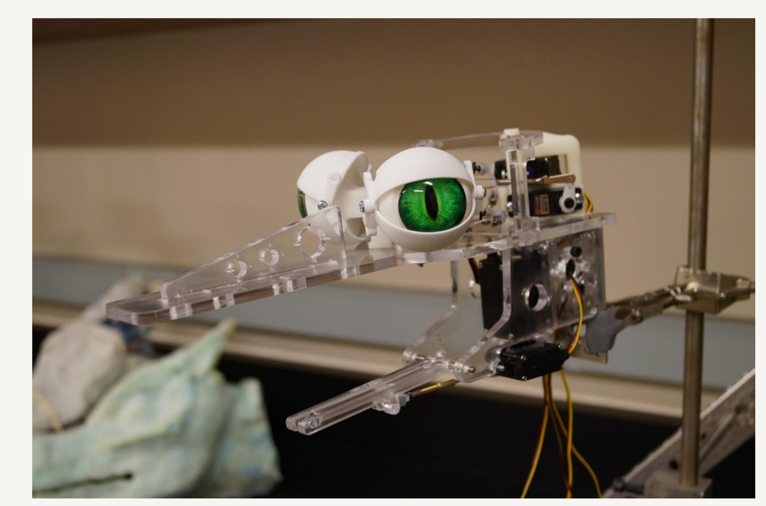
- The outputs of the dragon include a head with four degrees of freedom, moving jaw, blinking eyes, expanding wings, shifting tail and sound effects.



- The animatronic dragon, Kronos, was custom designed and fabricated for research purposes. The dragon sits atop a table that houses electrical and mechanical components. The table is approximately 32 inches deep and 42.5 inches in width. The dragon is affixed to the table; the majority of the motion capabilities are involved with the head and neck. This allows for the dragon to "watch" humans. Most of the hardware components were housed underneath the table in order to reduce mechanical noise and ease of maintenance and assembly.



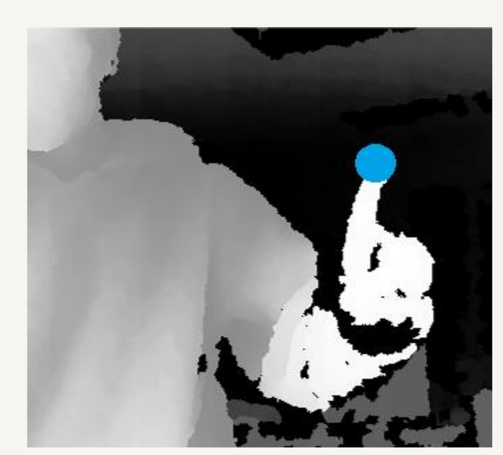




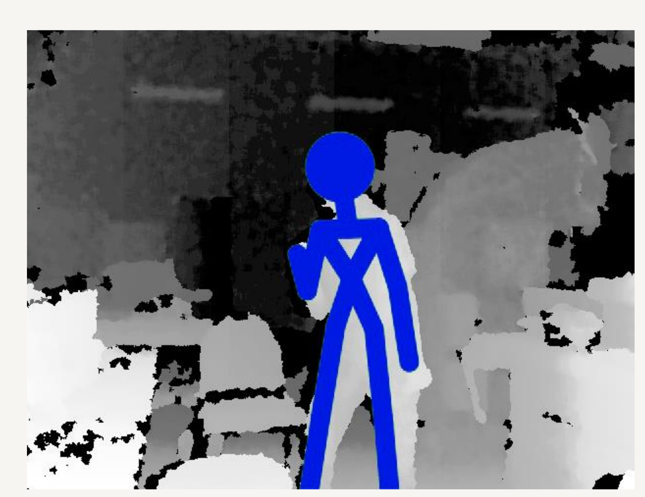
Vision and Control

- The key input to the dragon for interactive behavior is the depth camera. The PrimeSense Carmine was chosen for the project and is pictured in the image below.

- A depth camera holds a large advantage over a color camera in many robotic applications. Instead of identifying objects based on color, objects are identified by pixel locations in space. In the images to the upper right, white pixels represent the closer objects to the camera while the black represents those that are farthest away. The projector emits an irregular pattern of infrared dots of varying intensities. The infrared camera recognizes the pattern and constructs a depth image.

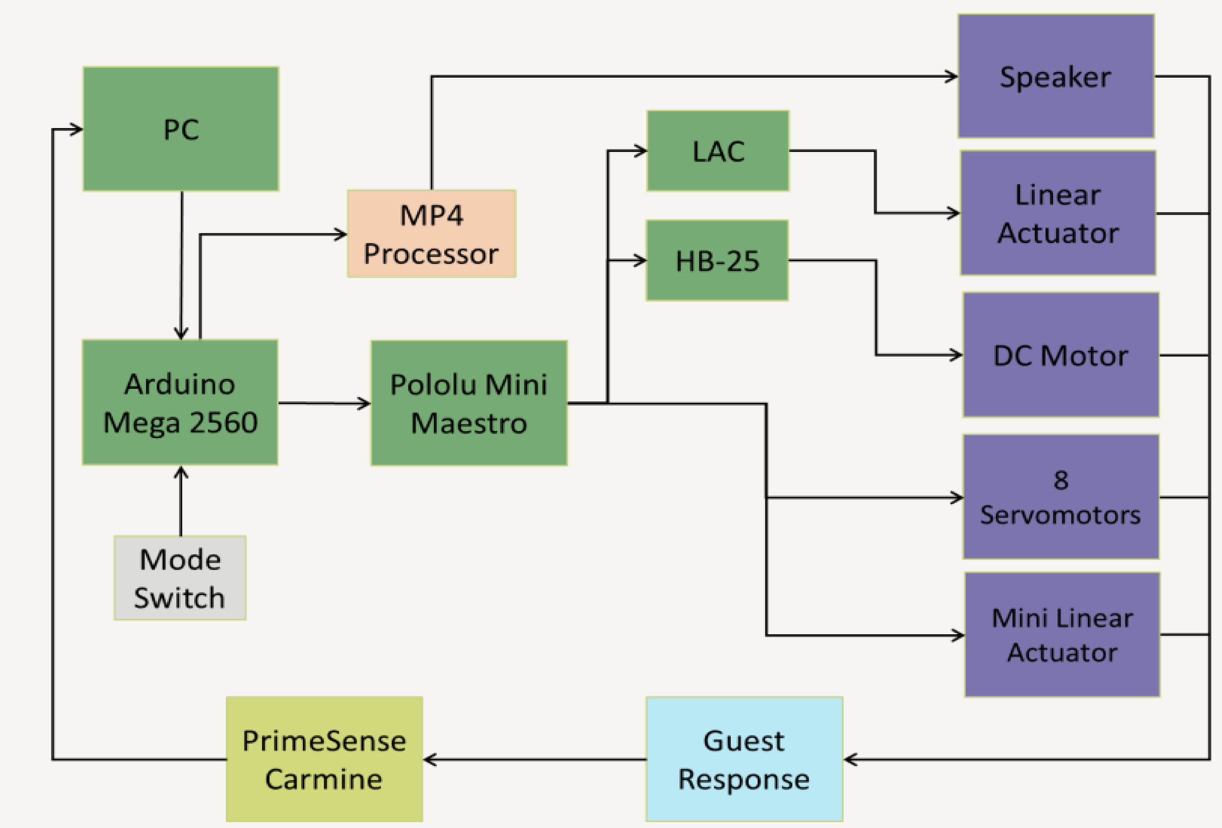


- To the left, is a screen capture of the program tracking the nearest pixel in the infrared image. A blue circle is drawn over the identified pixel.

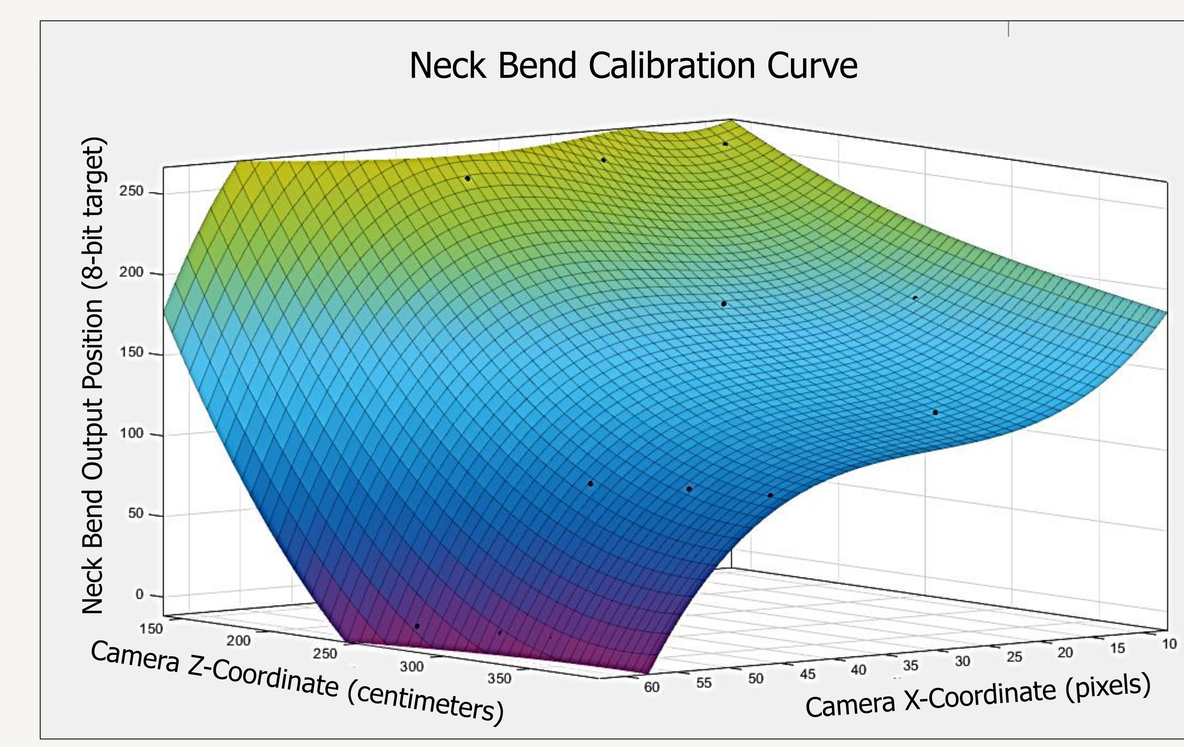


- The x, y, and z coordinates of the head position are recorded and sent to the microcontroller. The program is capable of tracking multiple people at once.
- All programming utilized OpenNI and NITE middleware libraries inside the Java-based Processing software. The software initiates a "handshake" with the Arduino microcontroller in order to relay the coordinates. The microcontroller serves as the central 'hub' of control and utilizes calibration equations to turn the coordinates into position commands for the motors and actuators, as well as, signals to the audio processor.

Hardware



- The above diagram displays the control flow diagram for the interactive, animatronic system. The interactive behavior is a closed loop system while passive behavior is open-loop.
- Mechanical positions were recorded in parallel with the coordinates of a tracked person in order to develop calibration curves. A surface curve equation of best fit was implemented into the Arduino microcontroller for successful calibration of people tracking.



Conclusion

- Kronos has been fully fabricated and implemented. Small improvements are being made to improve robustness and life cycle use of the entire system. Future work will include the integration of the system into a cloud robotic network and facial expression recognition.

Acknowledgements

- I would like to thank Justin Hinckley for his fantastic work on the sculpture of Kronos, Dr. Brian Vlcek and Dr. Biswanath Samanta for the research opportunity, and my family for their continued support and contributions.

Want to see Kronos in action? Go to: thebrianburns.wordpress.com