EXECUTIVE SUMMARY

This project aims to create a prototype wheelchair ramp with a mechanized awning made up of an array of finger-like structures mimicking the human hand, which open up as the user moves through them, increasing space around them. The interactive structure can be placed at entryways into buildings and is designed to integrate the disabled into public spaces where they experience neglect. The project comprises 3 main components: Design a structure to support the interactive fingers, design the pulley system to transmit lifting force to the fingers, and develop pneumatic muscles to actuate the pulley system.

“The Hand” design which incorporates these features was chosen through concept generation with our sponsor and a prototype design is presented. Analysis of the structure’s components is featured to prove the design concept.

The cantilevered structure is first analyzed. The structure is required to withstand possible placement outside and thus endure wind loads of 90 MPH. Analysis was completed to verify that the structure could withstand the stress 90 mph winds created at the base, with a resulting safety factor of 9. Spacing for dowel bar supports to prevent buckling of the structure was determined while designing the structure to meet ADA requirements of a minimum pathway width of 5’ and vertical clearance of 8’.

The pulley system is an interconnected system of 6 pulleys designed to effectively move the armatures. The system can be optimized to generate high mechanical advantage and achieve high degrees of motion. For analysis of the full-scale structure, it was determined that the pulleys satisfy the specification of 60 degrees of motion, while requiring 215 pounds of force from the muscle.

The McKibben actuator was evaluated experimentally to validate theoretical predictions. Testing was performed to evaluate the influence of muscle length, bladder thickness, fiber angle, applied force, and system pressure has on muscle contraction and actuation time. Testing indicated that muscle performance was repeatable where the deviation between repeated trials was less than 0.5%. However, the test results departed from the theoretical models, showing wall thickness and length have a greater influence on performance. It was observed the contraction of the muscle is reduced when the length is increased. This effect is minimized when the bladder thickness is increased. The testing series effectively illustrated the general influence the different physical parameters have on performance; however more testing is required to accurately predict muscles outside of the test range. From testing we were able to meet the sponsor requirements for the full size muscle in terms of operating pressure, actuation time, diametric expansion, and lifting capacity. Due to time constraints cyclic durability was performed to 1,600 cycles rather than the targeted 3,000.

We used the full-scale structural analysis to develop a 1:6 scale prototype. The prototype has the purpose of validating the motion from the pulleys while displaying key features of the full-scale model.