Team Door to Door: QuickLatch

Objective

- **General Need for Product**
  - People often have hands full when returning home for the day.
  - Hands-free front door opener would be beneficial.
  - No more fumbling for keys and struggling with locks.

- **Market Size**
  - All houses and apartments have front doors (2.23 million households in Maryland alone).
  - 80% of these doors open inward (i.e., could be kicked open if both were moved out of the way).
  - Survey results indicate that about 60% of people would be at least somewhat interested in purchasing a hands-free front door opener.
  - $2.23 million x $60 x 60% = just over 1 million potential customers in Maryland alone.

- **Physics of Task**
  - Force required to depress bolt: approximately 46 N or 9.8 lb.
  - Hands required to actuate: approximately 24 N or 5.4 lb.
  - Torque required to rotate bolt: approximately 6.8 ft-lb.

- **Critical-to-Quality Engineering Characteristics**
  - Range of motion activation
  - Force required to activate
  - Torque of mechanical actuator
  - Phase angle of mechanical components

- **Streamlined House of Quality**
  - In-Doorknob Servomotor
  - Automated Door Handle
  - Automated Frame-Mounted Door Opener

- **Final Concept**
  - Design consists of a frame (1), the bottom which (2) serves as a shaft on which the servo motor (3) will be fixed.
  - The axle of the frame will include screws (4) or some other mechanism for fixing the frame in place (attaching it to a stud inside the wall, etc.).
  - Two protrusions extend from the top of the frame (4), onto which metal brackets (5) will be attached.
  - These brackets will support a nut or pivot (7).
  - The pivot will be positioned such that it cannot move easily with the teeth of the gear (6) that is fixed to the servo motor (3).
  - When activated, the servo will rotate a through a predetermined angle, advancing the pivot and pushing the door is pushed out of the doorframe, enabling the door to be locked open freely without using one's hands.

Design

- **Product Architecture**
  - User Power Source
  - In-Doorknob Servomotor

- **Geometric Layout - CAD drawing**

- **Prototype Operation**
  - The prototype shows that the design will disengage a door piston when actuated by a sensor, which would allow for hands-free access to the user.
  - Test that the bolt can travel the correct distance given the thread and frame area designed.
  - Prove that the servomotor can provide enough torque to disengage a door piston.
  - Show that the design will actuate through use of sensors.
  - Prove that code holds door unlocked for desired time.

- **Prototype and Testing**
  - **Prototype Operation**
    - The prototype was tested by activating the Arduino code which starts the servomotor.
    - As the gear rotates, it moves the piston in a linear distance to compress the door piston.
    - 50 trials were completed to ensure unbiased results and to show design flaws.
    - The prototype was test by activating the photo-resistor, then monitoring the gear interaction and piston compression.
    - A sample of our data is shown below for different trials. Each trial shows where any design flaws lie. Trials such as trial 1 showed us that the piston was not moving far enough. Trials such as trial 3 showed us that there were flaws in the frame that did not keep the servomotor engaged.

  - **Prototype vs. Design: Key Differences**
    - Arduino used for actuation in prototype.
    - Design will include RFID or Bluetooth sensor sensor (not optical sensor).
    - Final product will run off house's power grid and backup battery (prototype runs on Arduino power source).

- **Testing Procedure**
  - Problem of unlocking and opening front door with hands still fully functional.
  - Data gathered to help determine most effective solution.
  - Possible concepts generated and analyzed.
  - Selection process refined ideas to final concept.

  - Embodiment and detail design led to final product design.
  - Prototypes and testing led to identification of problems and possible future work.

Test Results and Future Work

- **PDP Summary**
  - Problem of unlocking and opening front door with hands still fully functional.
  - Data gathered to help determine most effective solution.
  - Possible concepts generated and analyzed.
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  - Embodiment and detail design led to final product design.
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- **Reflection and Future Work**
  - Further research into less expensive remote sensor technology.
  - Customization of servomotor.

- **Test Results**
  - **Original test results showed that the prototype worked effectively approximately 35% of trials.**
  - **Failures resulted from slipping in the gear track. We must deepen the grooves of the gear track to be more effective.**
  - **Additional modifications to the frame design and code allowed for a much higher success rate of approximately 90%.**
  - **Testing showed that the servomotor provided the specified torque to slide the bolt and fully compress the piston.**