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Soft Robotic Grub

Will Anderl, Kaitlyn Bickmore, Nathan Jensen, Austin Stevens, Jeff Williams
Advisors: Drs. Henry Fu and Kam Leang
Department of Mechanical Engineering, University of Utah, Salt Lake City, Utah

Background

Most commonly, white grubs such as the chafer beetle larvae cause serious damage to residential lawns. These pests, however, can also attack gardens, fields, and other areas of agricultural operation. Dr. Fu is preparing to study methods of pest control relating to how the grubs move in the soil [1]. Live grub behavior is difficult to control in a lab setting, so studying grub movement becomes challenging. We have been tasked to design a robotic grub that is able to perform the same motions as a grub in a controlled and repeatable manner for Dr. Fu's force measuring test environment.

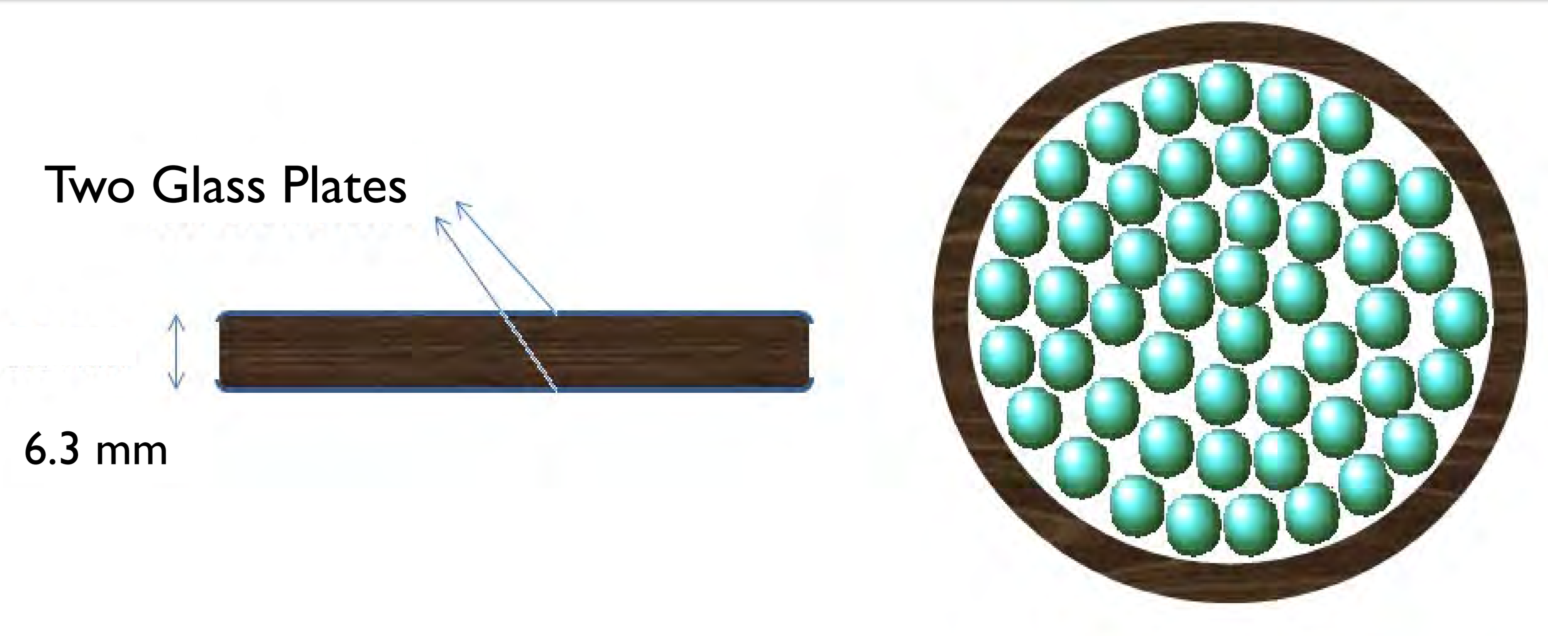
Project Goals

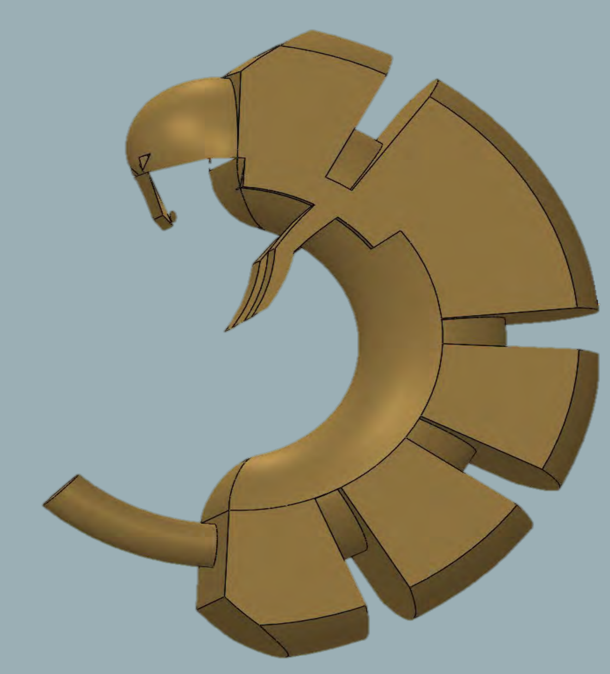
Manufacture as Soft Robot that mimics a grub with the following functions:

1) Use the body to move inside the grub burrow
2) Use the head to shovel dirt
3) Use the legs to collect the dirt freed by the head.

Challenges: Grub geometry must be limited to a maximum width of 6.3 mm

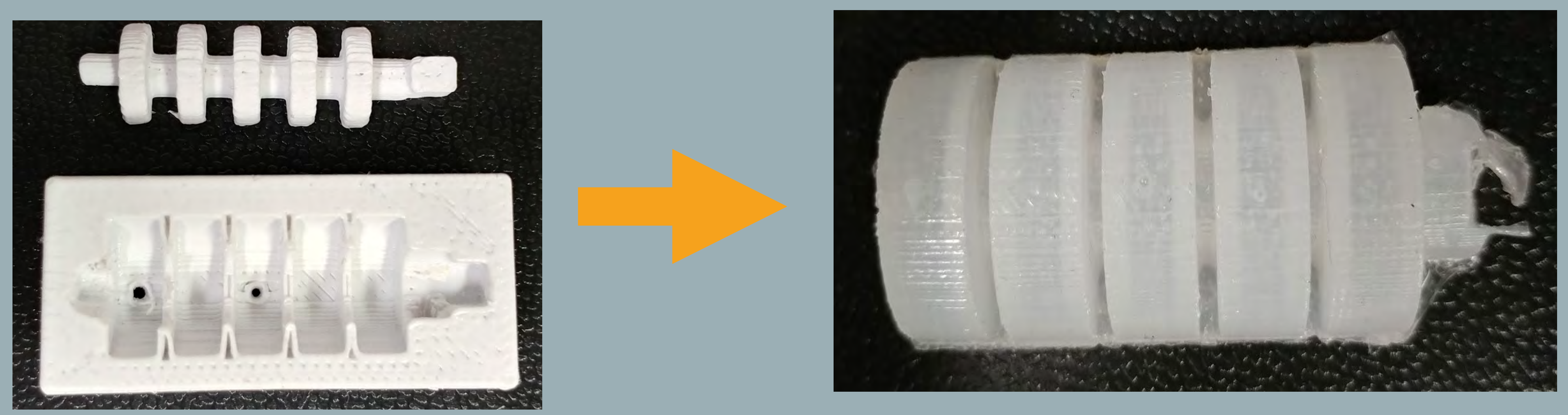
Test Environment



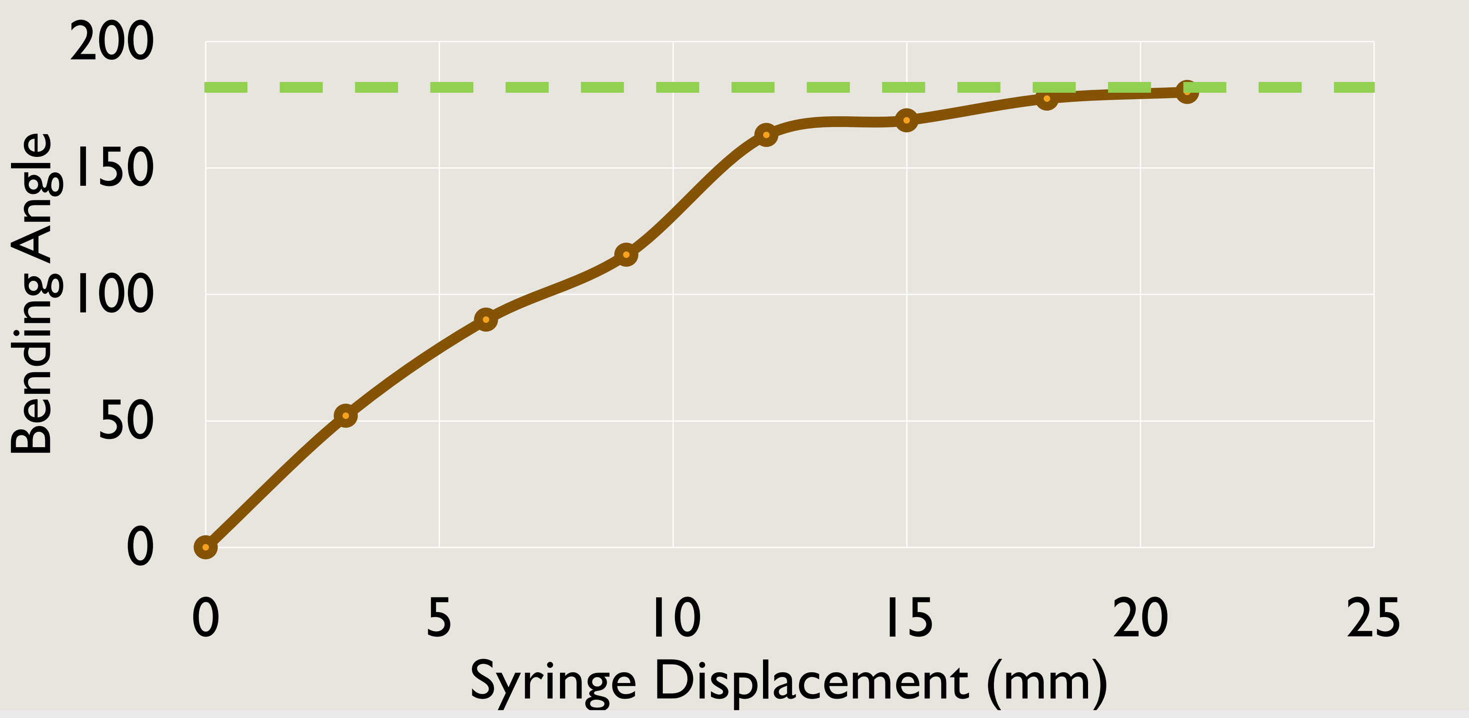


Manufacturing

The grub is manufactured from 3D printed molds and Dragonflex silicon. The molding process is completed in a degassing chamber to reduce the amount of air bubbles. The design consists of a large bellow for the body and head and 3D printed legs that are attached to the bellow. The proportions of the manufactured grub are the same as a natural grub.



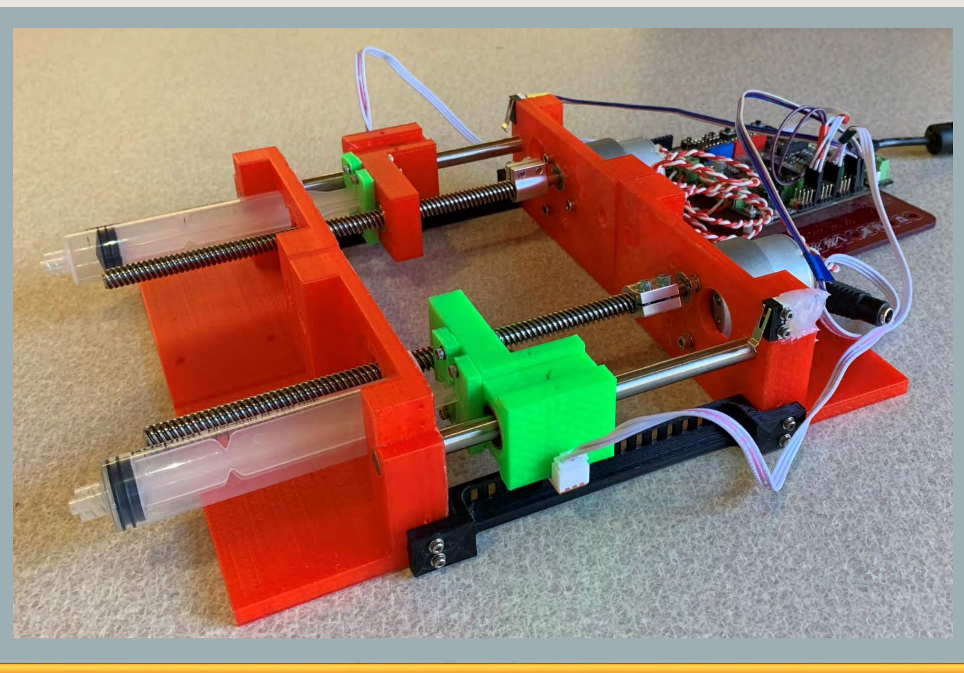
Bellow Deformation



Specifications for the bellow design was to achieve an angle of up to 180° of deformation when attached to the syringe pump.

Actuation

The actuation of the grub is controlled using Robotic Operating System (ROS) and a syringe pump. A syringe pump was chosen over a pneumatic pump because it provides the user with more motion capabilities The manufactured grub can complete the desired motions of a live grub.



Conclusion

In order to better understand grub movement, our team successfully created a soft robotic grub, capable of mimicking movements seen in naturally burrowing grubs. The motions achieved include flexion of the body and flexion of the head and arms. The major challenges our team faced included material selection and manufacturing pressure vessels at a small scale. A flexible silicone material was selected, and several iterations of molds were created to have a complete working grub. Our team successfully addressed these design challenges to produce a working grub robot.

Acknowledgements/References

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[1] Mirbagheri, S., Ceniceros, E., Jabbarzadeh, M. et al. Exp Mech (2015) 55: 427. https://doi.org/10.1007/s11340-014-9958-z