LEMELSON-MIT

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$10,000 "Eat it!" Lemelson-MIT Student Prize Undergraduate Team Winner

Grain Weevil: A grain extraction and bin management robot

The Challenge: Between harvest and distribution, grain is often stored in large bins on farms. There are over one million grain bins across the United States, collectively providing storage capacity for 13.5 billion bushels of grain.[1] To maintain the quality of the grain for sale, moisture and overheating must be prevented during storage. Grain also must be routinely levelled to maximize storage capacity. If conditions in the bin are not properly maintained, the grain can be damaged or clump together, forming a crust of hard grain on the top surface. The grain may also stick to the interior walls of the bin, making it difficult to extract. These scenarios lead to post-harvest grain loss. Estimated pre-consumer grain loss in developed countries like the U.S. equates to 12% of grain supply, and another 18% is lost as consumer waste.[2]

Proper grain management can be difficult, dangerous, and deadly. Technology provides farmers with data about the conditions within a grain bin. Grain management, however, must be done manually. Farmers and their children (sometimes as young as 14) must ensure that grain is level and properly aerated by entering the grain bin, enduring temperatures of up to 140 degrees Fahrenheit, to physically move grain with shovels or other tools. U.S. farmers put their lives at risk by entering grain bins where they may suffer illness, injury, entrapment, and even death. On average, one in five grain bin accidents involves a boy in his teens — in 2019 there were eight known accidents involving teenagers.[3] Up to 7% of farmers in the U.S. develop a disease commonly known as farmer's lung[4] brought on by an allergic reaction to grain dust that causes lung inflammation, shortness of breath, increased heart rate, cough, and sometimes permanent lung damage. Farmers typically live just eight years after diagnosis.

Developing technology to address grain management is difficult due to the nature of grain in storage, which moves and functions in fluid ways, with hot pockets of air creating a quicksand effect. There have been no machines to date that have been able to successfully navigate the top surface of the grain while avoiding entrapment in the grain.

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[1] "Wisconsin Ag News – Storage Capacity." United States Department of Agriculture, 2021. https://www.nass.usda.gov/Statistics_by_State/Wisconsin/Publications/Crops/2021/WI-Grain-Storage-01-21.pdf.
[2] HODGES, R. J., et al. "Postharvest Losses and Waste in Developed and Less Developed Countries: Opportunities to Improve Resource Use." The Journal of Agricultural Science, vol. 149, no. S1, 2010, pp. 37–45., doi:10.1017/s0021859610000936.
[3] Cheng, Yuan-Hsin, et al. Purdue University, 2020, pp. 1–17, 2019 Summary of U.S. Agricultural Confined Space-Related Injuries and Fatalities.
[4] Ohshimo, Shinichiro, et al. "Hypersensitivity Pneumonitis." Immunology and Allergy Clinics of North America, vol. 32, no. 4, 2012, pp. 537–556., doi:10.1016/j.iac.2012.08.008. https://www.medscape.com/answers/299174-115637/what-is-the-prevalence-of-hypersensitivity-pneumonitis-hp-in-the-us.

The Solution: Ben and Zane invented the Grain Weevil, a grain bin safety and management robot that weighs less than 30 pounds. The Grain Weevil is small enough to fit in a backpack and uses horizontal augers and gravity to level and redistribute grain within a bin.

Grain Weevil robotic device.

The robot rests on two augers that propel it forward and simultaneously do the work of leveling and aerating the grain by scurrying across the top surface without flipping over or getting buried. The drilling action of the augers, in conjunction with the natural force of gravity, facilitates grain movement and maintains appropriate viscosity, moisture levels, and temperature. The Grain Weevil is waterproof and dustproof, and is able to dig itself out from as much as five feet of grain if it is accidentally buried.

The Grain Weevil can be transported in a specially-designed backpack, allowing it to be easily carried to the top of a grain bin for placement inside. The robot is currently operated via remote control, but a fully autonomous self-driving vehicle is close to completion. Battery life for the Grain Weevil is approximately three hours. A longer battery life is anticipated, which will allow for a full maintenance cycle to be completed with only one charge.

Commercialization: Nearly 450,000 U.S. farms ranging from small family farms to large corporate operations have grain bins.[5] The Grain Weevil addresses safety and grain management across both areas and meets the quality standards of large corporate farms. Ben and Zane plan to have a service model that includes customers purchasing one Grain Weevil per grain bin for continuous bin maintenance and service calls as needed. Over the course of one year, the Grain Weevil will pay for itself in savings from preventing lost grain products. The team has one full utility patent pending and a second one near completion.

[5] Farm Safety Survey Public-Use Data, 2006, 2011. National Institute for Occupational Safety and Health (NIOSH), Jan. 2014, www.cdc.gov/niosh/topics/aginjury/fss/.