Make It Real CAD Engineering Challenge

Team: BCUZ

Clemson VEXU Robotics

Submission: Low Profile Omni-Wheel

Omni-directional motion is a vital aspect of most wheeled robotics platforms, and as such having access to a variety of omni-directional capable wheels is key in designing space efficient and effective robot platforms. One issue surrounding the current array of VEX EDR and VEXpro omni wheels is the lack of a low-profile, small diameter wheel.

The low-profile omni-wheel has a diameter of two inches, smaller than all other omni-wheels currently in the VEX ecosystem. The wheel is also only 0.415 inches in diameter, less than half the thickness of a 3.25 inch VEX EDR Omni-wheel. The low-profile omni-wheel uses 6 rollers from a 3.25 inch EDR omni-wheel to achieve translational motion. The rollers are held in place by a two-piece bolt together clamshell with interlocking ridges and a square mounting hole for high strength axles or high strength inserts.

The combination of a both the smaller diameter wheel and the thinner width allow for the wheel to excel in situations where a lightweight low drag solution is needed, or where space is at a premium. Two such cases were encountered in the design and construction of the 24 inch and 15 inch BCUZ robots. Low-profile wheels were a key part in developing a tracking system for the robots. Using three of the low-profile wheels coupled to encoders allows the robot to determine its current position on the field, a useful feature for long autonomous routines. The small diameter and width were crucial as there was not enough room between the drive channels of the robot to fit conventional omni-wheels and encoders. The low-Profile omni-wheels were also used in the anti-tip mechanisms of both robots. This application is perfectly suited to the wheels as there is not a substantial amount of load applied, however a low drag solution is needed to prevent loss of drive power. There are almost an unlimited number of situations where a low-profile, lightweight omni-wheel would be a beneficial design element.

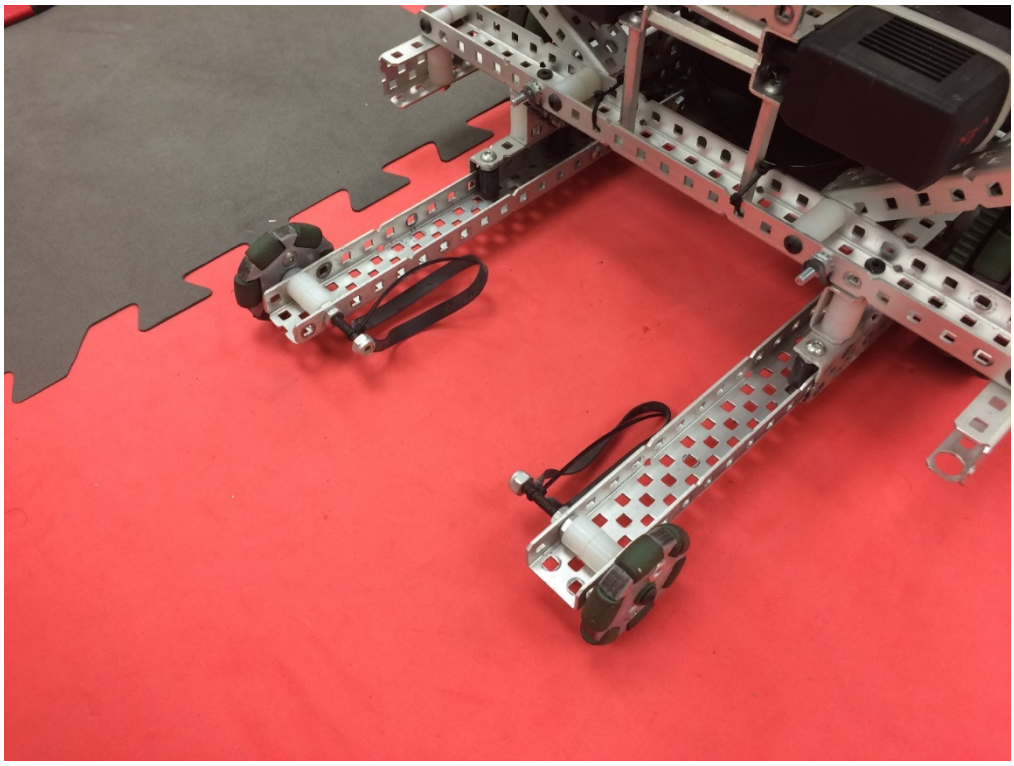

Image 1: Low-profile omni-wheels being used as anti-tip rollers on the 24 inch robot

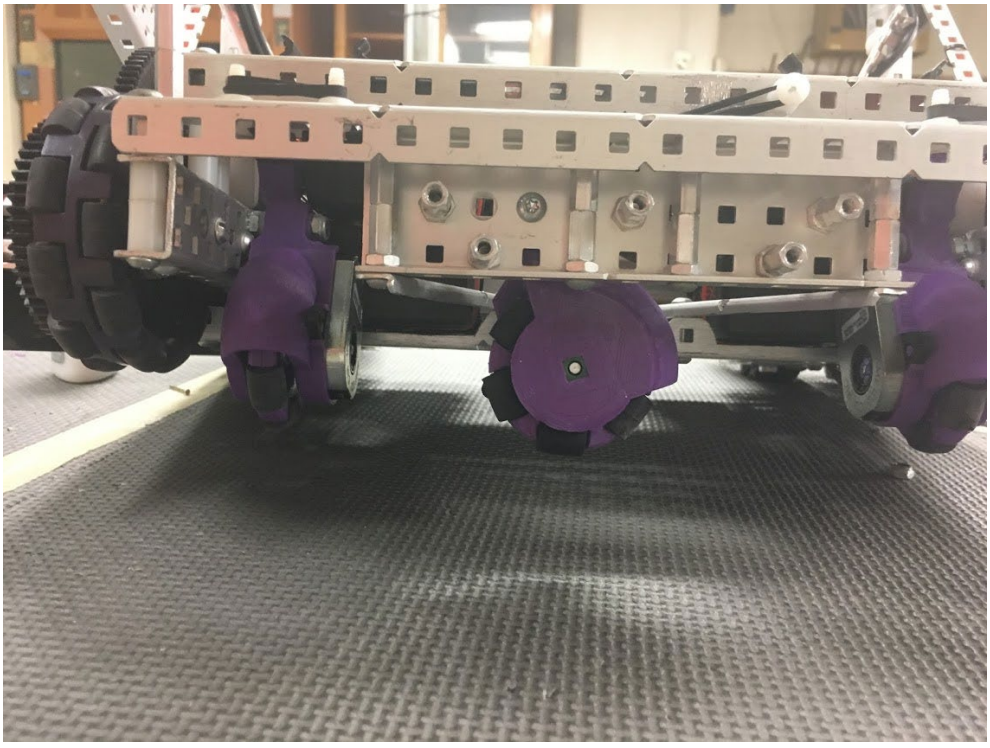

Image 2: Odometry setup on the 15 inch robot using the low-profile omni-wheels

An iterative design process was used in the development of the low-profile omni-wheel. Beginning in June the problem was identified that space would be the limiting factor for any odometry system added to the robot. To resolve this issue the first prototype was modeled using Autodesk Inventor 2017 Student. An omni-wheel roller from a VEX 3.25 inch omni-wheel was brought into an inventor assembly containing the hub. The roller was constrained to the hub, allowing for clearances and tolerances to be checked. This wheel was a one-piece assembly where the rollers would be pressed into slots from the side. The advantage of this design was its extreme simplicity, however there were drawbacks to this design. Getting a proper press fit was challenging given the tolerance of the FDM printers, the wheels were also subject to cracking upon assembly. When modeling the wheel hub only one of the cutouts for the roller and axel were added, the rest were derived from a circular pattern of the original cutout. This allowed for rapidly changing the dimensions of roller and axle cutouts without having to change each roller cutout individually.

Image 3: Initial one-piece design with slots for installing rollers from the side of the hub

To resolve these design issues a two-piece assembly was used. By splitting the hub of the wheel looser slots could be used for mounting the roller pins without fear of them falling out. The two-piece assembly also greatly reduced the risks involved in the assembly of the first iteration wheels.

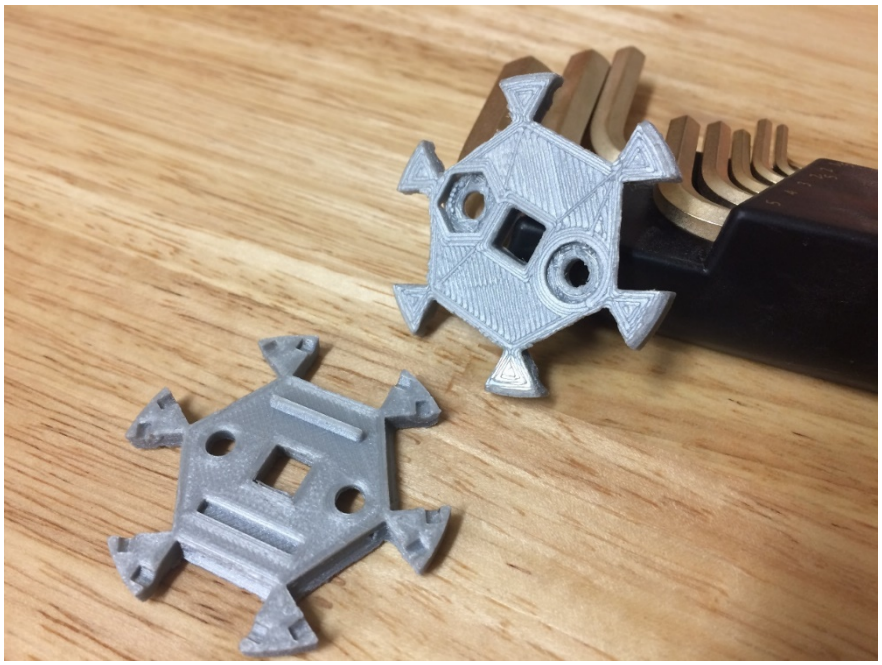

Image 4: Initial clamshell design for the hubs with the alignment features

An inventor assembly was created from the two hub halves and the omni-wheel rollers and pins. Using this assembly two mating alignment features were added to the hubs to ensure proper alignment and contribute to the ease of assembly of the wheel. The tolerances and positions of the hubs were checked using cutaway section views of the wheel.

Image 5: Assembled wheel using the clamshell hub design and round high strength shaft inserts

To further reduce the complexity of the wheel it was decided to make both halves of the hub identical. This was achieved by using a hex relief on both bolt holes on the hub. By making the hubs identical both ease of manufacturing and assembly of the omni-wheels and wheel hubs is increased.

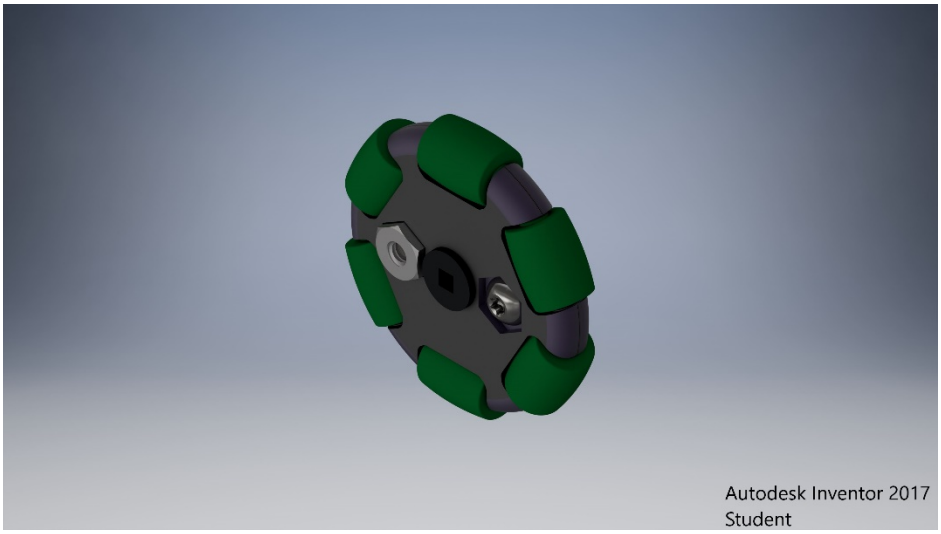

Image 6: Render of the low-profile omni-wheel

The design process for the low-profile omni-wheels has led to several considerations for future development projects, the two most outstanding of which are the need to simplify the designed component and to design components for manufacturability. Having a simpler design allows for fewer failure modes and allows for faster fabrication and assembly of components. The need for a simple design also leads into the need to design for manufacturability. As was learned from the original hubs, the method of manufacturing must be considered when designing component tolerances. Having the larger tolerances afforded by the clamshell design made manufacturing of the wheel hubs much easier by eliminating the need for deburring inside corners or filing away slight interferences in the roller axle slots.

3D design software will continue to be a fundamental part of the competitive robotics environment. This is especially true of the VEXU program where more advanced forms of manufacturing are allowed. Not being able to utilize 3D modeling software hampers the team's ability to design effective, custom components using advanced manufacturing techniques. This shift towards utilizing 3D modeling software is not limited to competition robotics, as advanced manufacturing techniques become more common in industry it will become necessary to be fluent in multiple 3D design software's. All the students on the BCUZ team who have participated in an engineering internship or Co-Op have utilized some form of 3D modeling software.