# 6 - Hole Positions

## 6.1 - Hole Patterns

In order to properly attach pieces to each other, multiple fasteners must be used. If only one is used, the parts are still free to rotate about the fastener hole, so at least two are usually necessary. The pattern in which these holes are arranged depends on the type and strength of the fasteners.

Rivets are usually arranged in square patterns, with consistent spacing between them. This offers great strength and redundancy, so that even if a few rivets break, the joint is still strong. And, since the CNC router makes drilling several holes very easy and because rivets are easy to install, having a large number of rivets in a joint does not greatly increase the time it takes to build it. The pattern tool in Inventor can make it easy to model these kinds of hole patterns.

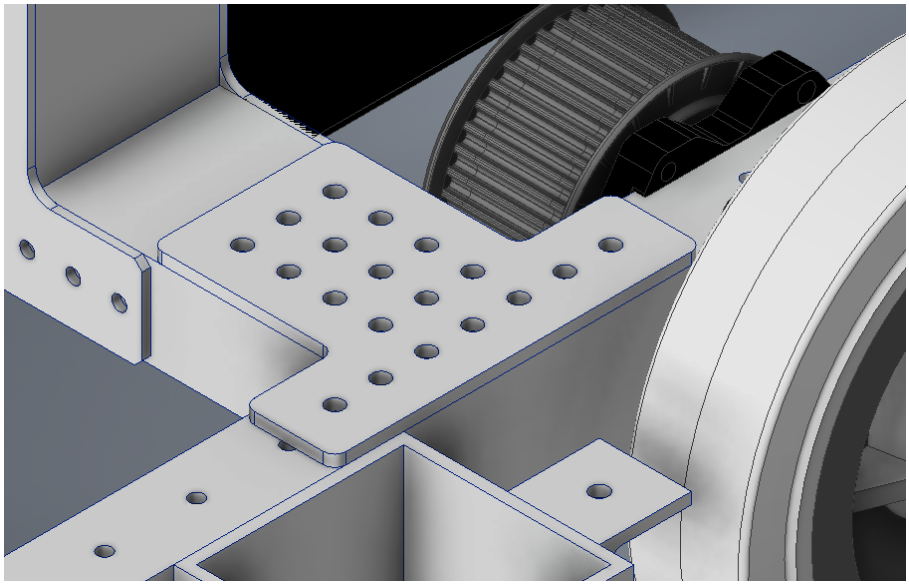

Figure 7: A gusset on the 2019 robot which uses a rivet pattern. Each rivet is 0.5" from the next one in all directions. Note that the rivets are not modelled in CAD.

Bolts, on the other hand, are not usually used in these kinds of patterns. Because bolts are somewhat heavy, it is best to use as few of them as possible, so they are often used in pairs of two.

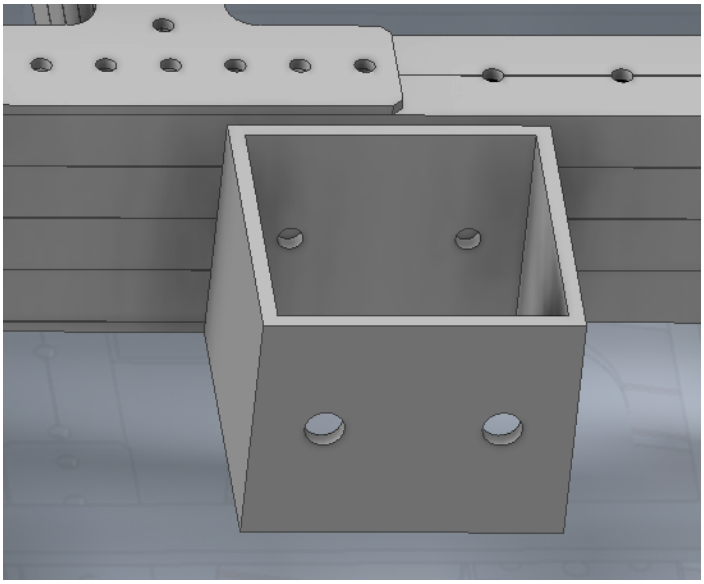

Figure 8: A bumper mount on the 2017 robot, with only two bolts used in the joint. Note that, again, the fasteners are not modelled

## 6.2 - Match Drilling

Recall that a clearance hole for a bolt is only slightly larger than the diameter of a bolt itself. For instance, a 0.203" (13/64") clearance hole for a 0.19" wide 10-32 bolt, there is only 0.0065" of space on either side of the bolt. This is a very small size, and it means that in order for holes to line up correctly, they must be drilled to a very tight tolerance, in most cases more precise than our build team can produce. Therefore, we use match drilling to account for this.

In match drilling, the holes are built into only one of the parts, not both, and your CAD models should reflect this. Then, to assembly the pieces, the parts are clamped together and a hand drill is used to transfer the holes from the first part to the second, ensuring that they line up properly. For the sake of your CAD models, in most cases you should only model holes on one part. For instance, if you need to attach a gusset to a tube with rivets, you should model the holes on the gusset but not on the tube.

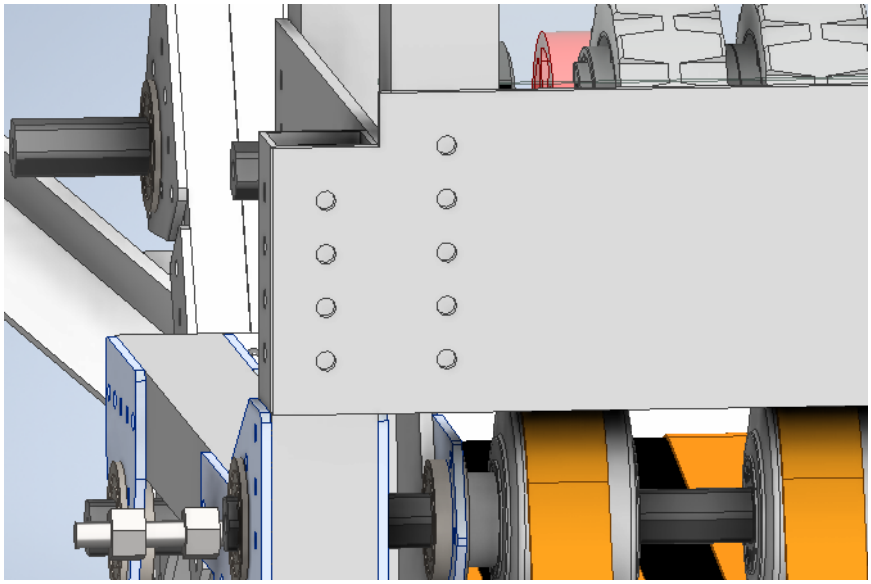

Figure 9: Match drilled holes on the 2017 robot. The holes are only modelled in the flat piece in front, not in the tubes.

# Design Challenge 6: Assemblies with Fasteners

Find the assembly "DC6_ASM.iam" in File Explorer, and copy it to your own directory. This is an incomplete hypothetical assembly that has a few parts, all in their desired positions, but it still needs all of its fasteners designed. The 1" x 1" tubes should be attached to the 2" x 1" tube by two 10-32 socket-head bolts and nuts. Then, the plates should be attached to the 1" x 1" tubes by a pattern of 3/16" rivets spaced 0.5" apart.