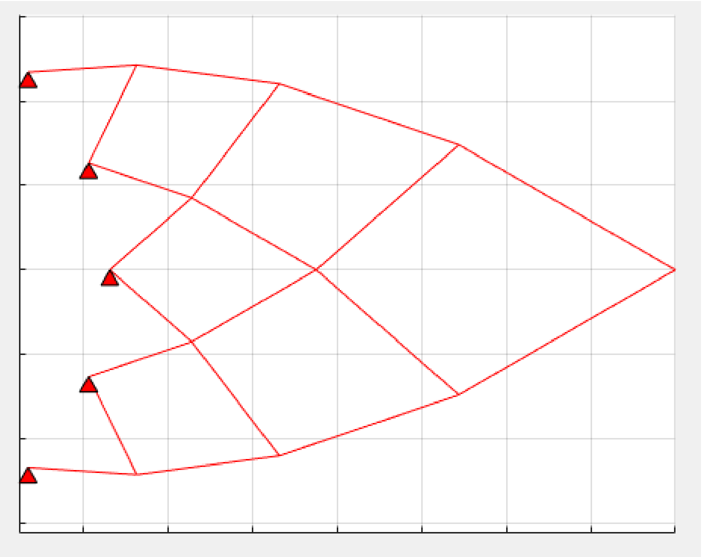
Mitchell Truss of order 4

System properties:

The unloaded structure is constructed below.



From calculation, we have mhat=nhat=r, so the structure is neither potentially inconsistent nor underdetermined. This means that the equations of static equilibrium have exactly 1 solution, which is called static determinance. That is, no matter what external force is applied, the force distribution in each member of this structure is solvable and unique.

Test cases of external forces:

According to Bob, the force direction in all members is known if the direction of external force lies in the shaded region with an angle of 2/3 pi.

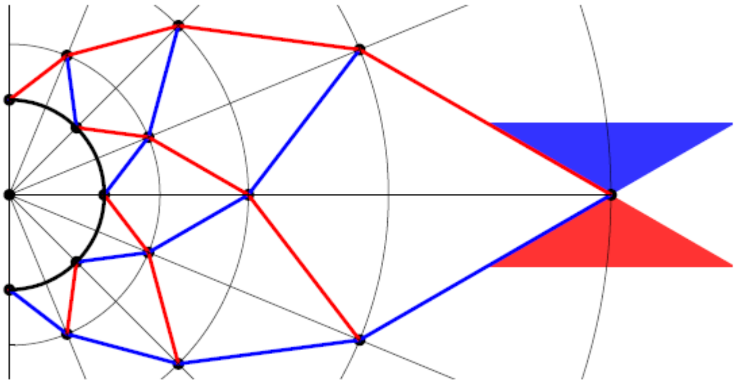
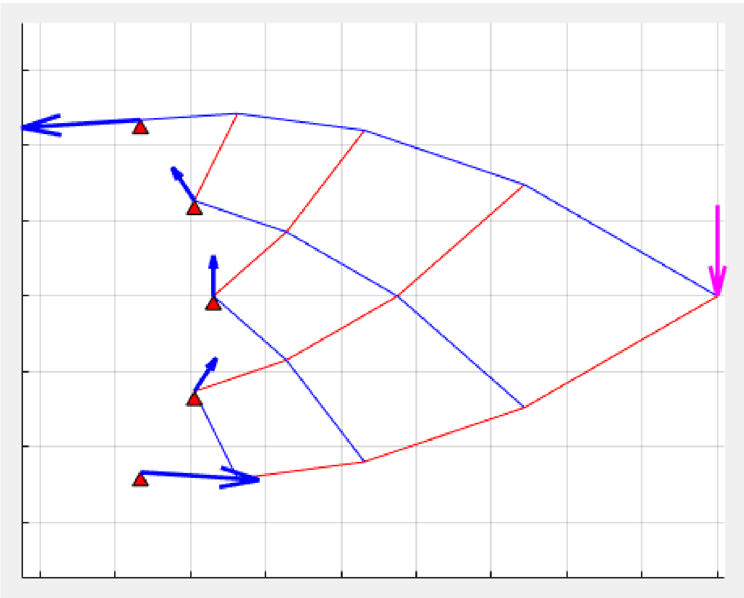


Fig.2. Michell Topology of Order 4 ($\varphi = \pi/16$, $\beta = \pi/6$) showing bending region; blue and red indicate a member in compression or tension.

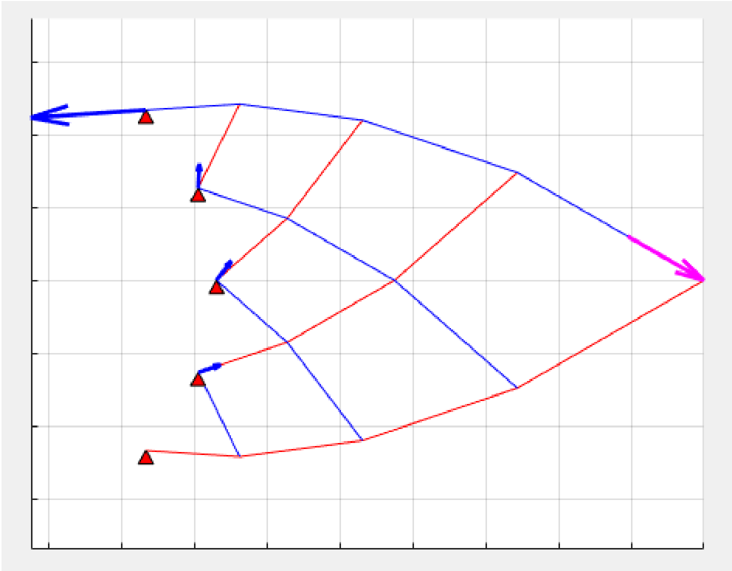
Here we tried 3 different external forces. (We can refer those bars in tension to strings for convenience of discussion)

Case 1. External force lies in the shaded region: u=(0,-1)



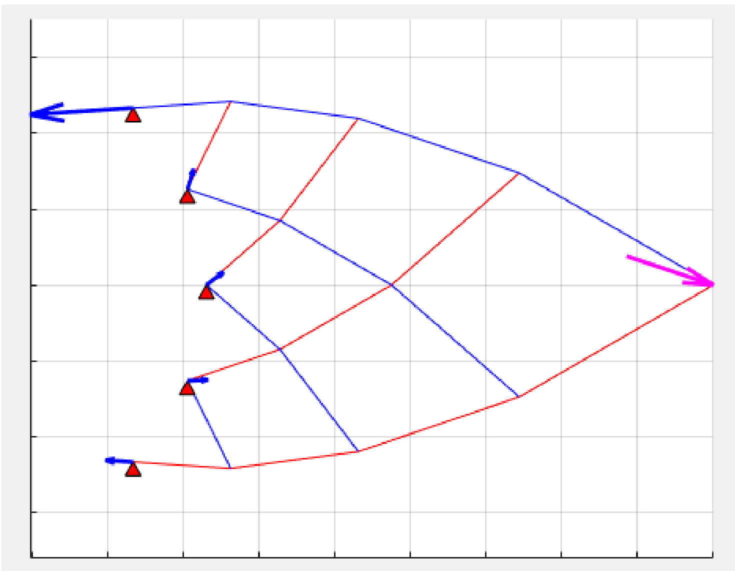
Results show that all force directions satisfy the expectation. Here we use blue lines to represent bars in compression and red lines are bars in tension.

Case 2. External force lies on the edge of shaded region: u=(sqrt(3),-1)



Results show that all bars are under compression. Though no strings are compressed, there exists several strings with zero loads. That is, some members can actually be removed without influencing the static equilibrium.

Case 3. External force lies out of the shaded region: u=(3,-1)

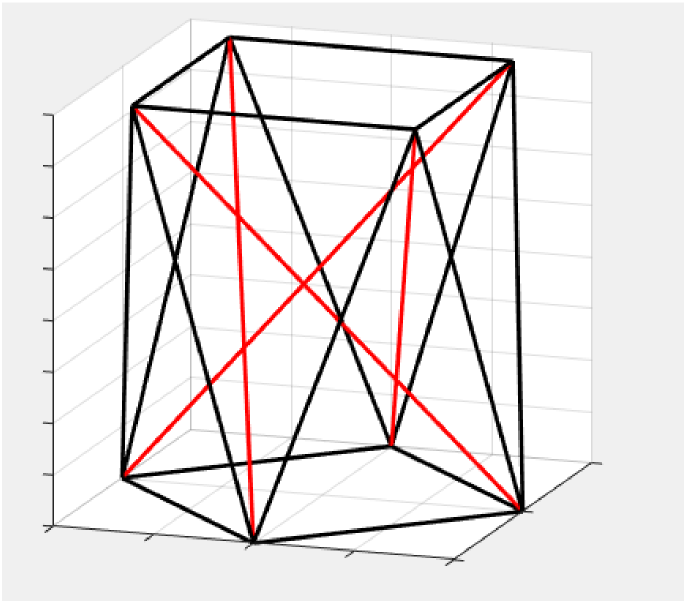


Results show that some strings are under compression, which is not desired. For such external force, the force direction in each member can't be predicted.

Non minimal tensegrity prism with 4 bars

System properties:

In my setup, the two polygons on top and bottom have the same radius of 2. The twist angle is pi/4 and the height is 4.



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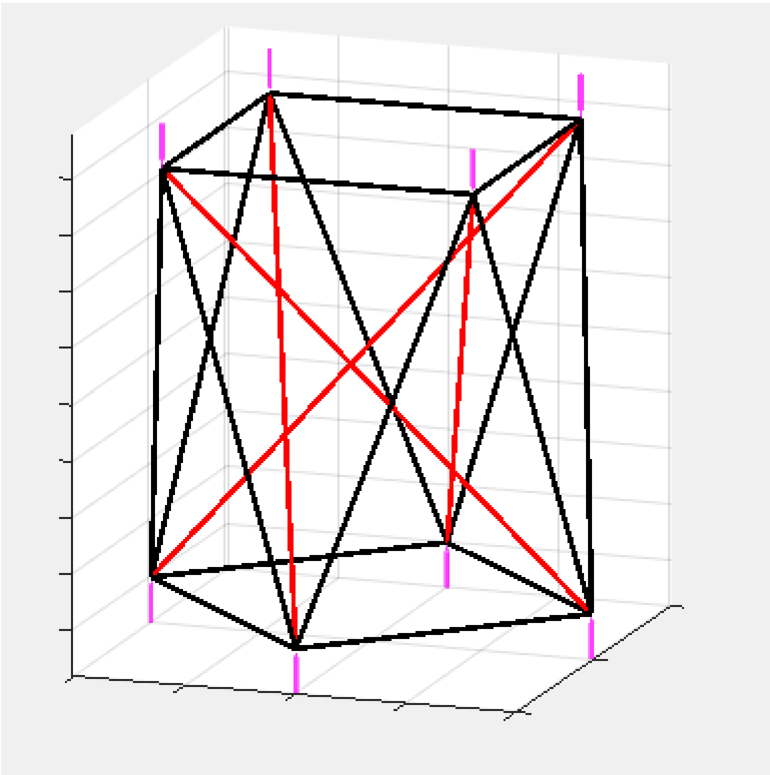
The structure is potentially inconsistent. This means that instability or soft modes exist. Any small deformation of the structure may lead to failure. To remove the potentially inconsistency, several strings should be added properly, increasing the number of independent rows in Ase.

It's also underdetermined, which means there are fewer independent equations than unknowns, so no unique solution is expected for any external loading profile. There exists 3 degrees of freedom in the structure.

To figure out whether the system is pretensionable, we apply zero loads and check the force in each member. The results show that all members are under zero loads when no external force is applied, thus it is not pretensionable. That is, the structure is tensionable under load, which means there exist some external force profiles that can make all strings under tension.

Test cases of external forces:

Applying an external force that distributes equally on top and bottom surface but with opposite direction gives us an example of underdetermined case.



Results show that some strings are under compression, needing additional tensioning.