Kalli Albright
March 2nd, 2018
D1: DASL UAV Antenna Gimbal
Mobility and Kinematic Analysis
ME486C-2
Tuesdays 5:30-8pm

Introduction

This report will discuss and analyze the mobility of the gimbal system and kinematic advantages and disadvantages. The mobility will be analyzed using Gruebler's equation to determine the number of required input motions. Results drawn from this analysis will help the team confirm if their decision of a single input source will be successful creating the predicted output.

Assumptions

The first critical assumption to be made is that all linkages are rigid bodies and will not deform under external forces. This is crucial to kinematic analysis since link lengths need to stay constant and no forces are absorbed by deformation. Additionally, it will be assumed that only significant movements of joints will determine the joints order (i.e. small translation in purely rotating joints will be ignored).

Analysis

Degrees of freedom is defined as "the number of independent relative motions among the rigid bodies" [1]. Gruebler's equation (1) supplies the number of degrees of freedom of a mechanism. [2]

$$M=3(L-1)-2J \tag{1}$$

where M is degree of freedom or mobility, L is the number of links, and J is the sum of order of joints. For a rigid body to be considered a mechanism and not a structure or preloaded structure, $M \geq +1$. A mechanism is defined as "a device that transform motion to some desirable pattern and typically develops very low forces and transmits little power" [2]. This equation will supply the appropriate number of independent input motions required. A kinematic model of the DASL UAV Antenna System is shown in Figure 1.

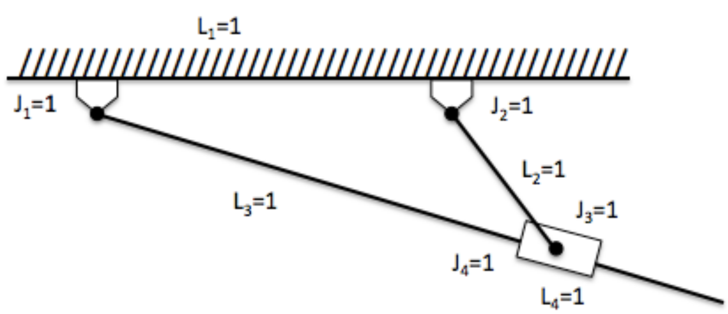

Figure 1: Kinematic Model

L_1 is defined as the ground link, which would be the UAV's modular housing and mounting brackets. L_2 is the cam arm, L_3 is the antenna, and L_4 is the pivot base. J_1 and J_2 are grounded rotating full joints. J_3 is a moving rotating full joint. And J_4 is a moving translating full joint. This gives the system L=4 and J=4. When substituted into Gruebler's equation, gives an M=1. Therefore the system can be classified as a mechanism and needs a single input motion.

Results

The team's current design has kinematic advantages because it only requires a single input source therefore confirming the team's decision to use a single servomotor. Since kinematics is commonly used for DC motor driven mechanisms using a 360-degree crank, the team could explore adding a simple dyad designed using kinematic principles to restrict the antenna's positions. The obvious downside to using a DC motor and designing a dyad is the limited space for the mechanism. Therefore the team is continuing with this current design and using a servo where the rotation can be restricted in the software.

References

[1] Zhang, Y., Finger, S. and Behrens, S. (2018). *Chapter 4. Basic Kinematics of Constrained Rigid Bodies*. [online] Cs.cmu.edu. Available at: https://www.cs.cmu.edu /~rapidproto/mechanisms/chpt4.html [Accessed 2 Mar. 2018].

[2] Norton, R. (2012). *Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines*. 5th ed. New York: McGraw-Hill, pp.4,40.