

Linear Algebra in Aerospace Engineering

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Rotations

One of the main applications of linear algebra within Aerospace engineering is the use of rotation matrices. Rotation matrices can be used to describe the roll, pitch, and yaw of a spacecraft, which represent rotation about the x , y , and z axes respectively. This from Glenn Murray's *Rotation About an Arbitrary Axis in 3 Dimensions*, [1]

Roll:

$$R_x(\gamma) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \gamma & -\sin \gamma \\ 0 & \sin \gamma & \cos \gamma \end{bmatrix}$$

Pitch:

$$R_y(\beta) = \begin{bmatrix} \cos \beta & 0 & \sin \beta \\ 0 & 1 & 0 \\ -\sin \beta & 0 & \cos \beta \end{bmatrix}$$

Yaw:

$$R_z(\alpha) = \begin{bmatrix} \cos \alpha & -\sin \alpha & 0 \\ \sin \alpha & \cos \alpha & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Statics

Statics also makes use of the principles of linear algebra. The whole idea of statics is taking the sum of the forces in the x and y directions– as well as the net torque– to be zero.

$$\sum F_x = 0 \quad \sum F_y = 0 \quad \tau_{\text{net}} = 0$$

These formulas provided by Professor Wolfson in his *Essential university physics* [2]. This usually involves identifying all the forces in the problem, and summing them up to zero. This is at it's heart a giant homogeneous linear algebra problem. It would also be *really* interesting to see if the solution to an engineering problem you found was guaranteed to be unique, or if there might be another solution that you're missing.

Component Connections

Again this is not strictly an Aerospace engineering application, but more of an engineering application in general. When working with a large system, it's helpful to know which parts connect to each other, and the distances between each of the components.

Problems like this can be solved by creating a matrix with one row and one column for each component, then putting a 1 for connections between components, and a 0 for components that don't connect. [3]

References

- [1] Murray, G. (2013, June 6). *Rotation About an Arbitrary Axis in 3 Dimensions*. Retrieved March 10, 2016, from <http://inside.mines.edu/fshome/gmurray/ArbitraryAxisRotation/>
- [2] Wolfson, R. (2012). Essential university physics. Boston: Addison-Wesley.
- [3] Trudeau, R. J. (1993). Introduction to graph theory. New York: Dover Pub.