This document will explain the algorithm of calculating the rotate angle when the boat is rotating. Suppose the target rotation matrix of the plane and the rotation matrix of the boat are known as R\_target (3\*3) and R\_boat (3\*3). Since the plane can only rotate about its own z-axis and y-axis, two variables are used (a and b) to represent the corresponding angle to rotate around z-axis and y-axis. Rz(a) (3\*3) and Ry(b) (3\*3) represent the rotation matrix of the rotating the plane around z-axis and y-axis. Finally, the equation can be established as following:

R\_boat \* Rz(a) \* Ry(b) = R\_target

The final target is to calculate the value of a and b based on various R\_boat and R\_target.

Rz(a) \* Ry(b) = R\_boat -1\* R\_target (1.1 Multiply the inverse of R\_boat to each side)

Let R\_modify = R\_boat -1\* R\_target

Rz(a) \* Ry(b) = R\_modify

To solve this equation, it’s necessary to look into these matrices.

Rz(a) = [cos(a) –sin(a) 0; sin(a) cos(a) 0; 0 0 1]

Ry(b) = [cos(b) 0 sin(b); 0 1 0; -sin(b) 0 cos(b)]

Rz(a) \* Ry(b) = [cos(a)\*cos(b) –sin(a) cos(a)\*sin(b);

sin(a)\*cos(b) cos(a) sin(a)\*sin(b);

-sin(b) 0 cos(b) ;]

Suppose the value of R\_modify is as following:

R\_modify = [A11 A12 A13;

A21 A22 A23;

A31 A32 A33]

Since the value on entry (3,2) is always 0 and it’s highly possible that the corresponding value of R\_modify is not 0, no matter how we change a and b, probably this equation can’t be solved. However, as long as the plane is facing the sun, it’s still acceptable to modify the R\_target. Since after applying the rotation, z-axis of the plane should be parallel to the sunlight, it’s necessary to keep the proportion of the third column of R\_modify.

(sin(a)\*sin(b))/(cos(a)\*sin(b)) = A23/A13

tan(a) = A23/A13

a = arctan(A23/A13)

a = atan2(A23, A13) (in Matlab)

(sin(a)\*sin(b))/cos(b) = A33/A23

b = arctan(A23/A23/sin(a))

b = atan2(A33/A23, sin(a)) (in Matlab)

This algorithm shows the procedure to calculate two rotation angles of the plane. Since the algorithm only keeps the feature of unchanged direction, phenomenon that the plane’s spinning around the z-axis (pointing to the sun) can be observed during the simulation.