Brigham Young University

AUVSI Capstone Team (Team 45)

Geolocation Algorithm Description

ID	Rev.	Date	Description	Author	Checked By
IM-004	1.0	12-12-2018	Initial release	Connor Olsen	Tyler Miller

Contents

```
clear
clc
```

Initial Parameters

These initial parameters represent data that will be readily accessible on the MAV. Pixel Array, Field of View angle are specifications of the camera, and the normalized line of sight vector (l_cusp_c) will be determined by either the autonomous detection program, or the manual interface clients.

```
% The X and Y pixels denote the location of the target in the image plane
% and are centered about the center of the image, with +x extending to the
% 'right' and +y extending 'down'
x_pixel = 10;
y_pixel = 10;

M = 256; %square pixel array (width and height if square)
Ex = x_pixel/M; %X pixels, normalized
Ey = y_pixel/M; %Y pixels, normalized
fov_ang = pi/2;%sym('fov_ang'); %field of View angle --> A6000 83* - 32* (in radians)
f = M/(2*tan(fov_ang/2)); %focal length  in units of pixels

l_cusp_c = 1/sqrt(Ex^2 + Ey^2 + f^2) * [Ex;Ey;f];

roll = 0;%sym('roll'); %Radians
pitch = 0;%sym('pitch'); %Radians
yaw = 0;%sym('yaw'); %Radians

alpha_az = 0;%sym('az'); %Azmuth Angle: Should equal yaw.
alpha_el = 0;%sym('el'); %Elevation Angle: "Pitch" of the gimbal

StartingLat = 40.248459;
StartingLon = -111.645809;

%P vector should be in Meters
Pn = 20;
Pe = 20;
Pd = -100;%sym('Pd');

h = -Pd;%;sym('h');
k_i = [0;0;1];
```

Rotation Matrices

The location of the target is defined in the camera coordinate frame system, and must be transformed into the inertial frame to provide GPS coordinates. This transformation is done using three rotation matrices: Moving Camera frame to Gimbal coordinates; Gimbal coordinates to body frame; body frame to inertial frame

```
% R_b_to_i
% Found on page 15 of Small Unmanned Aircraft

R_v_to_b = [cos(pitch)*cos(yaw) cos(pitch)*sin(yaw) -sin(pitch); ...
    sin(roll)*sin(pitch)*cos(yaw)-cos(roll)*sin(yaw) sin(roll)*sin(pitch)*sin(yaw)+cos(rol
l)*cos(yaw) sin(roll)*cos(pitch); ...
    cos(roll)*sin(pitch)*cos(yaw)+sin(roll)*sin(yaw) cos(roll)*sin(pitch)*sin(yaw)-sin(rol
l)*cos(yaw) cos(roll)*cos(pitch)];

R_b_to_v = R_v_to_b'; %R_v_b is a translation of R_i_b. It may work, but I may need one mo
re step.
R_b_to_i = R_b_to_v;

% ------------------------------------------------------------------------
% R_g_to_b
% Found on page 227 of Small Unmanned Aircraft
R_b_to_g1 = [cos(alpha_az) sin(alpha_az) 0;...
    -sin(alpha_az) cos(alpha_az) 0;...
    0 0 1];

R_g1_to_g = [cos(alpha_el) 0 -sin(alpha_el);...
    0 1 0;...
    sin(alpha_el) 0 cos(alpha_el)];

R_b_to_g = R_g1_to_g*R_b_to_g1;

R_g_to_b = R_b_to_g';

% ------------------------------------------------------------------------
% R_c_to_g
% Found on page 227 of Small Unmanned Aircraft
R_g_to_c = [0 1 0;...
    0 0 1;...
    1 0 0];
R_c_to_g = R_g_to_c';

% For simplicity, the three Rotation matrices are combined into one below
RbiRbgRcg = R_b_to_i * R_g_to_b * R_c_to_g;
```

Geolocation Algorithm

The algorithm uses the line of sight vector in the camera frame and rotates it into the inertial frame. There, it is multiplied by a scaler (height) and divided by the projection of the transformed line of sight vector onto the unit vector k_i in the inertial frame

```
P_i_mav = [Pn;Pe;Pd];
P_i_obj = P_i_mav + h*(RbiRbgRcg*l_cusp_c)/(dot(k_i,(RbiRbgRcg*l_cusp_c)));
```

Publish

```
disp("Coordinates of the MAV");
disp(P_i_mav);

disp("Coordinates of the Target");
disp(P_i_obj);
```

```
Coordinates of the MAV
    20
    20
  -100

Coordinates of the Target
   1.0e+05 *

    3.2770
    0.0012
         0
```

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