Tank turret rotation

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1 Introduction

The objective of this report is to evaluate how to control the turret rotation and the gun elevation.

2 Coordinates

Let's consider the trigonometric circle as reference. The rotation is positive if it is following the trigonometric direction, which is anti-clockwise.
the turret is at a specified angle, α_{start}. a target is situated at an angle α_{finish} the turret must rotate in order to satisfy the following first condition :

$$\alpha_{start} = \alpha_{finish} \tag{1}$$

The second one is that this movement must take the shortest time.

3 Angle difference

The trigonometric circle is divided into 4 quadrants. When calculating the difference between angles, it is useful to know to which quadrant each angle belongs. In case of two neighbor quadrants, the difference is easily found. If the angles are in opposite positions (quadrant 1 and 3 or 2 and 4), there is two possibilities to compute the difference. Because we want to shortest path for the turret, the difference of angle should be :

$$\delta = \alpha_{finish} - \alpha_{start} <= \pi \tag{2}$$

In case the result does not fulfill this condition, δ must be computed table

Table 1: Holes and threaded holes

Screw	Threaded hole diameter	Bore Hole (clearance)
M3	2.8	3.2
4	35	144
5	45	300

Clearance To fix two part together, a clearance is needed. When two parts must be assembled together, a clearance of 0.1mm is enough. Then use the glue to fix the assembly.

Table 2: Nonlinear Model Results

Case	Method#1	Method#2	Method#3
1	50	837	970
2	47	877	230
3	31	25	415
4	35	144	2356
5	45	300	556

$$Length_{lattitude}(\phi) = 111132.92 - 559.82 \cdot cos(2 \cdot \phi) + 1.175 * cos(4 \cdot \phi) - 0.0023 \cdot cos(6 \cdot \phi) = ...[m/degree] \tag{3}$$

1 degree longitude at latitude phi

$$Length_{longitude}(\phi) = 111412.84 - 93.5 \cdot cos(3 \cdot \phi) + 0.118 \cdot cos(5 \cdot \phi) = ...[m/degree] \tag{4}$$

4 Schéma cinématique

4.1 Vecteurs positions

origine : centre de rotation verticale se trouvant sous les pâles principales.

position des pâles principales (pp) : vecteur verticale

position de l'hélice arrière : vecteur allant de l'origine vers l'hélice (h) arrière.

5 Angular momentum

5.1 Formula

$$\vec{L} = \vec{OA} \otimes \vec{P} = \vec{r} \otimes \vec{P} = \vec{r} \otimes m \cdot \vec{v} = \vec{I} \otimes \vec{\omega} \quad (5)$$

$\vec{L}$: Angular Momentum $[kg \cdot \frac{m^2}{s}]$
$\vec{OA}$ and r: position of the mass $[m]$ according to a referance
$\vec{P}$: linear momentum $[kg \cdot \frac{m}{s}]$[1]
$\vec{v}$: velocity $[\frac{m}{s}]$ I : moment of inertia $[m^2 \cdot kg \cdot]$
ω : angular speed $[\frac{rad}{s}]$
Torque :

$$M = \frac{d\vec{L}}{dt} = \frac{d(\vec{I} \otimes \vec{\omega})}{dt} \quad (6)$$

if we consider a particule of mass m, $\vec{r}$ is the position of the center of mass. If it is a solid object, L is first computed according to the axis of rotation of the object :

$$\vec{L}_{ar} = \vec{I}_{ar} \otimes \vec{\omega}_{ar} \quad (7)$$

To compute the angular moment according to an other axis of rotation (new referance), we use the Huygens-Steiner theorem (or the Parallel axis theorem) :

$$\vec{L}_0 = \vec{I}_0 \otimes \vec{\omega}_{cm} \quad (8)$$

$$\vec{I}_0 = \vec{I}_{ar} + m \cdot d^2 \quad (9)$$

with d the distance between the axis of rotation of the object and the new referance.

5.2 Condition of stability

Main rotor(s):

$$\vec{L}_{mr} = \vec{r}_{mr} \otimes m_{mr} \cdot \vec{v_{mr}} = \vec{I_{mr}} \otimes \vec{\omega_{mr}} \quad (10)$$

Rear rotor :

$$\vec{L}_{rr} = \vec{r}_{rr} \otimes m_{rr} \cdot \vec{v_{rr}} = \vec{I_r}r \otimes \vec{\omega_{rr}} \quad (11)$$

assurer la stabilité lors du vol: les moments cinétiques doivent s'annuler. (poser la formule et résoudre)

$$\vec{L_{mr}} = \vec{L_{rr}} \quad (12)$$

or
The generated torque is compensated :

$$\sum \vec{M_{mr}} = \sum \vec{M_{rr}} \quad (13)$$

find a relation between ω_{mr} and ω_{rr} -> determine the transmission ratio

[1] $\vec{L}$ is perpendicular to both $\vec{P}$ and $\vec{r}$

5.3 Pivots à droite et à gauche

pour tourner à gauche ou doite, on ne doit plus satisfaire la condition de stabilité. le pilote utiliser le pédalier pour accélérer/ralentir l'hélice arrière. ainsi les moments cinétiques ne sont plus égaux.

calculer l'effet de rotation sur l'hélicoptère si l'hélice est accélérée/ralentie de 10,20,30,.. $\%$. mettre un tableau. calculer la vitesse de rotation dans ces cas-là.

$$\begin{bmatrix} 0 \\ 0 \\ l_1 \end{bmatrix}_{R_1} \quad \vec{AB}_{R_2} = \begin{bmatrix} 0 \\ l_2 \\ 0 \end{bmatrix}_{R_2} \quad \vec{BC}_{R_3} = \begin{bmatrix} l_3 \\ 0 \\ 0 \end{bmatrix}_{R_3} \quad \vec{CD}_{R_4} = \begin{bmatrix} 0 \\ 0 \\ -l_4 \end{bmatrix}_{R_4} \tag{14}$$

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$$\begin{aligned} \vec{OE}_R = \vec{OA}_R + \vec{AB}_R + \vec{BB}_{1R} + \vec{B_1C}_{1R} + \vec{C_1C}_R \\ + \vec{CC}_{2R} + \vec{C_2D}_R + \vec{DD}_{1R} + \vec{D_1E}_R \end{aligned} \tag{15}$$

$$\begin{aligned} \vec{OF}_R = \vec{OA}_R + \vec{AB}_R + \vec{BB}_{1R} + \vec{B_1C}_{1R} + \vec{C_1C}_R \\ + \vec{CC}_{2R} + \vec{C_2D}_R + \vec{DD}_{1R} + \vec{D_1E}_R + \vec{EF}_R \end{aligned} \tag{16}$$

$$\begin{aligned} \vec{OG}_R = \vec{OA}_R + \vec{AB}_R + \vec{BB}_{1R} + \vec{B_1C}_{1R} + \vec{C_1C}_R + \vec{CC}_{2R} \\ + \vec{C_2D}_R + \vec{DD}_{1R} + \vec{D_1E}_R + \vec{EF}_R + \vec{FF}_{3R} + \vec{F_3G}_R \end{aligned} \tag{17}$$

$$\begin{aligned} \vec{OH}_R = \vec{OA}_R + \vec{AB}_R + \vec{BB}_{1R} + \vec{B_1C}_{1R} + \vec{C_1C}_R + \vec{CC}_{2R} + \vec{C_2D}_R \\ + \vec{DD}_{1R} + \vec{D_1E}_R + \vec{EF}_R + \vec{FF}_{3R} + \vec{F_3G}_R + \vec{GH}_R \end{aligned} \tag{18}$$

6 Conclusion