Line of Sight(LOS) Algorithm - Modeling and Evaluation

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Objective :

. To Design an LOS algorithm for 3 degree of freedom ship models which will track any kind of trajectories in all four quadrants and its evaluation by PID controller. Evaluation is performed for straight line in all four quadrants and Trajectories such Spiral, Fibonacci, Cardioid and Parametric Curves.

Algorithm Input : Ship Current state, Way points Analysis Report, History of the last way point used
Algorithm Output : Cross Track Error(CTE), Heading Error, Updated History

Ship Current State	$\longrightarrow$	$[u, v, r, x, y, \psi, t]$
Way points Analysis Report	$\longrightarrow$	$[A, B]$
History	$\longrightarrow$	[Preceding Quadrant, Preceding Way point, Flag, δ]

A contains,

1. Starting Quadrant
2. Major Quadrant of Way points
3. $Q1$ points, $Q2$ points, $Q3$ points, $Q4$ points and x and y axis points

B contains,

1. Quadrant Sequence
2. Separated way points according to quadrant sequence

While calling the LOS, first, it will find out the nearest way point. if the nearest way point is same as the way points in history, then the same points will be used for calculating Cross Track Error(CTE) and Heading Error. Otherwise, it will take next way point and update the history as well.

Normalizing Factor: LOS way point's angle is varying from $-\pi$ to π, while ship model's heading angle ranging from -2π to 2π. In order to get proper Heading Error, Normalizing ship model's heading angle is taken place.

Governing Equations: (with reference to Thor.I.Fossen LOS paper)

- Desired Heading Angle $\longrightarrow \psi_d = \gamma_p + arctan\left(\frac{-y_e}{\Delta h}\right)$ - β
- Horizontal Path Tangential Angle $\longrightarrow \gamma_p = arctan2((y_{k+1} - y_k), (x_{k+1} - x_k))$
- Beta angle $\longrightarrow \beta = arctan2(v, u)$
- Cross Track Error $\longrightarrow y_e =$ -$(x - x_k)$ $\sin(\gamma_p)$ + $(y - y_k)$ $\cos(\gamma_p)$
- Δh = $2 \times LPP$ (length between perpendicular)
- Heading Error (HE) = ψ_d - ψ_{actual}

Evaluation of LOS by PID Controller

Tracking the Straight Line in Four Different Quarants:

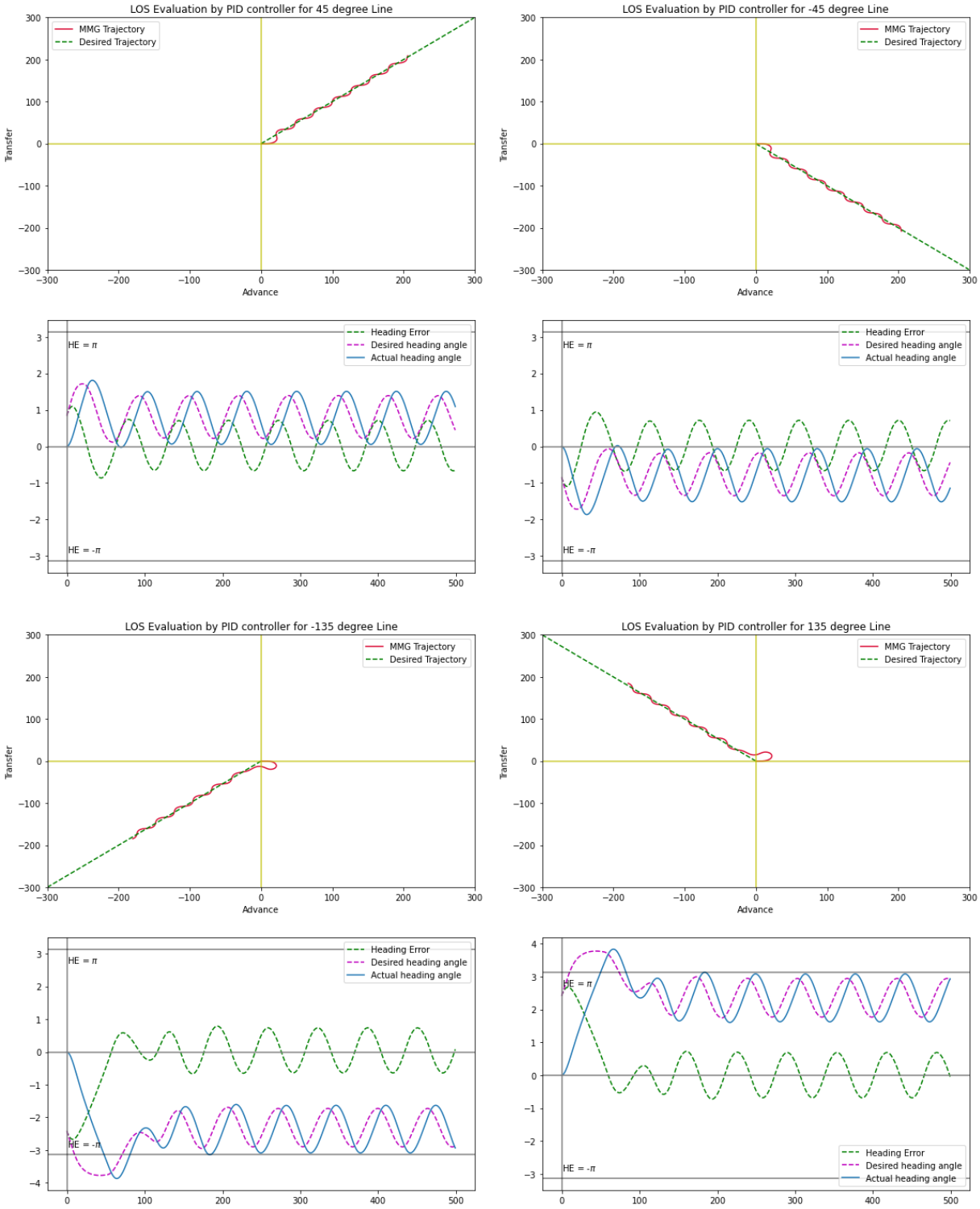


Figure 1 . Straight line in (45,135,-135,135) degree

Tracking the Straight Line in Four Different Quarants:

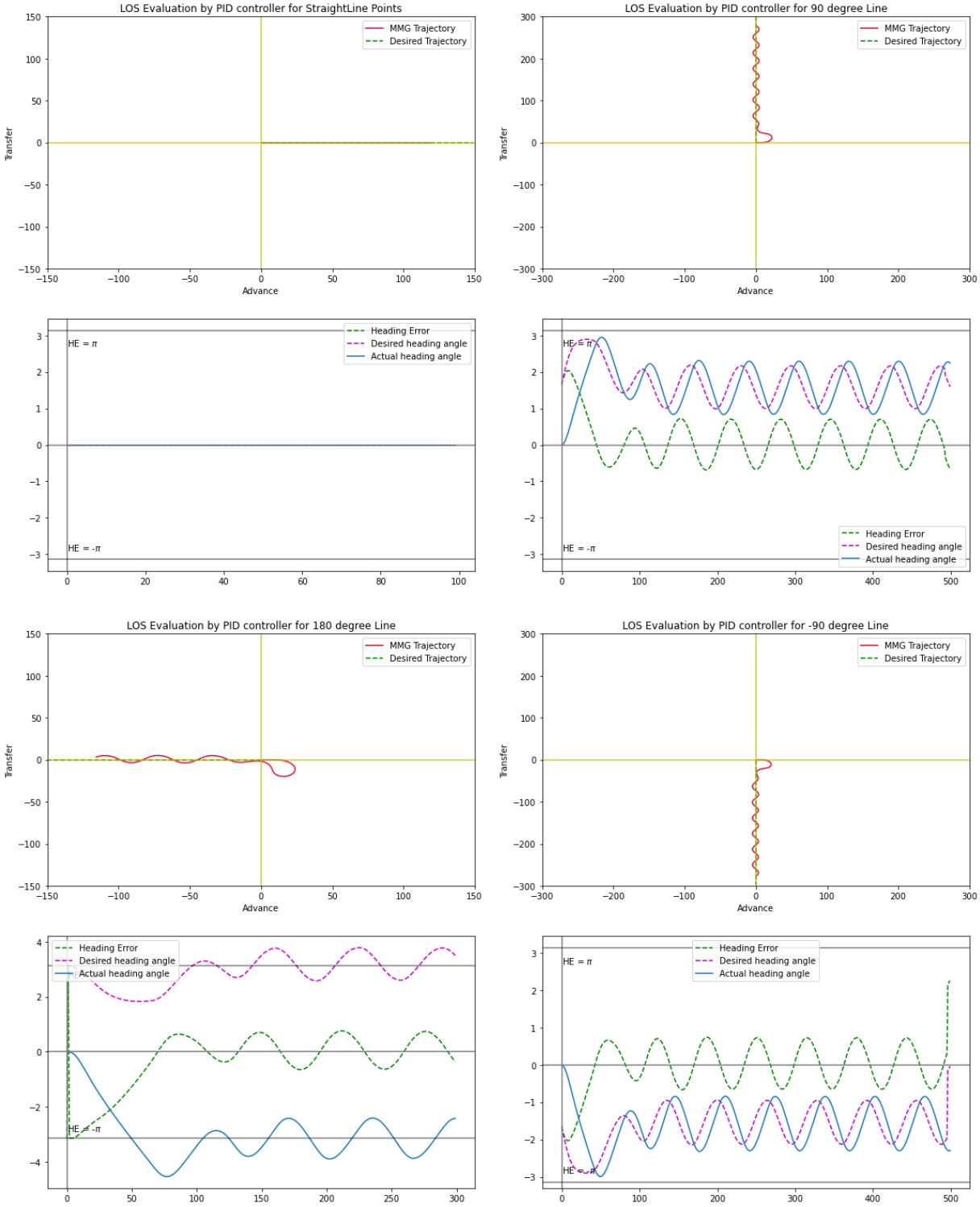
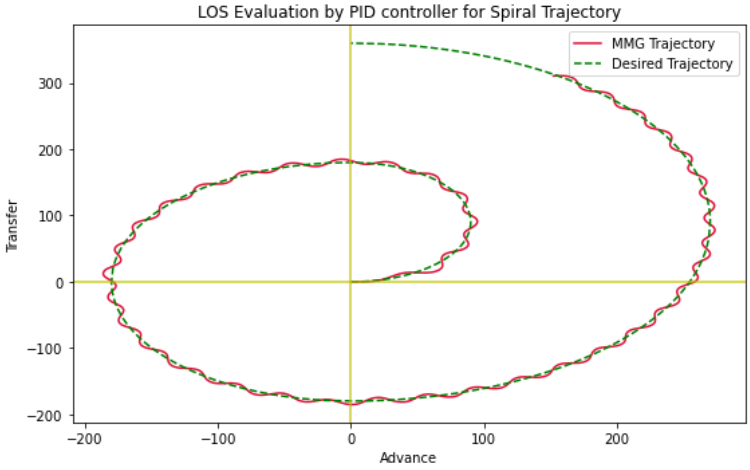
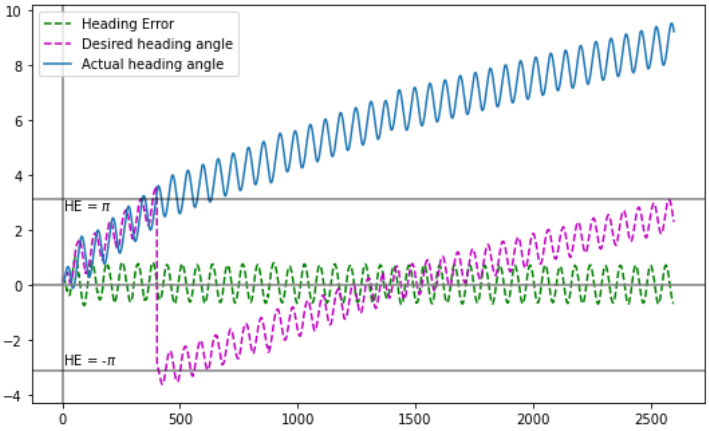


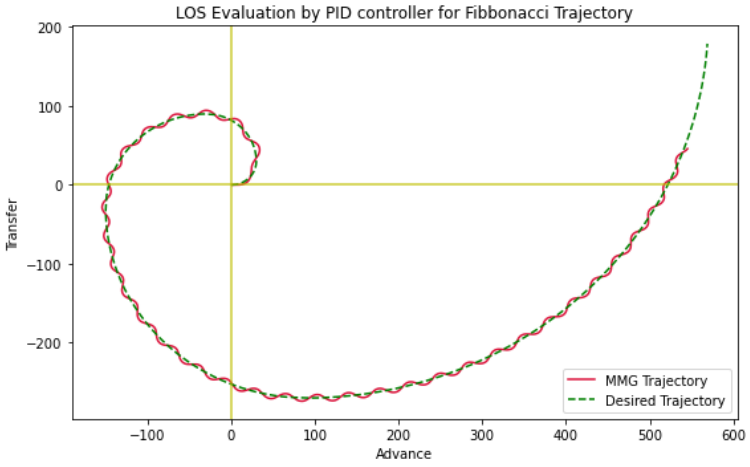
Figure 2 . Straight line in (0,90,180,-90) degree

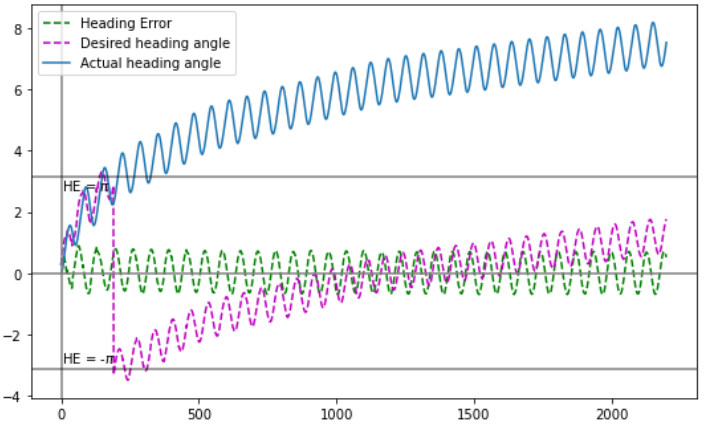
Spiral Trajectory:



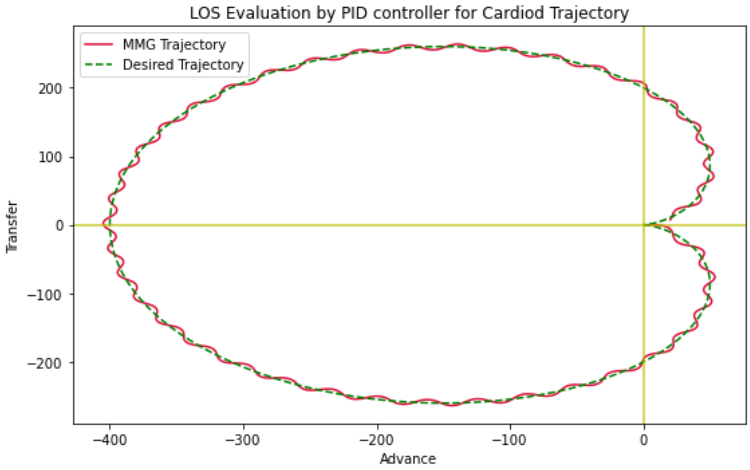


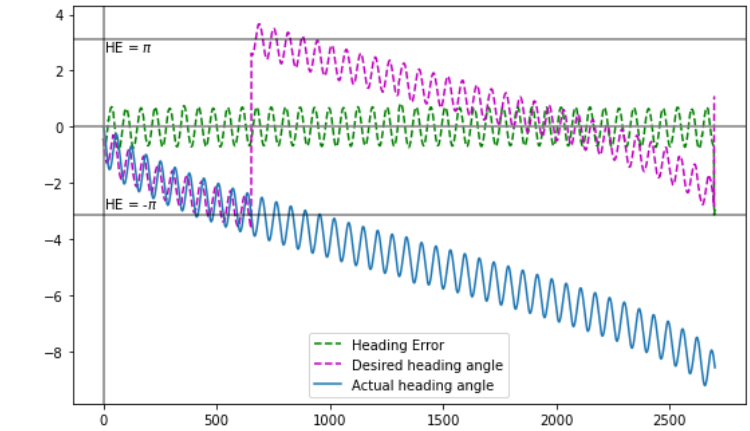
Fibonacci Trajectory:



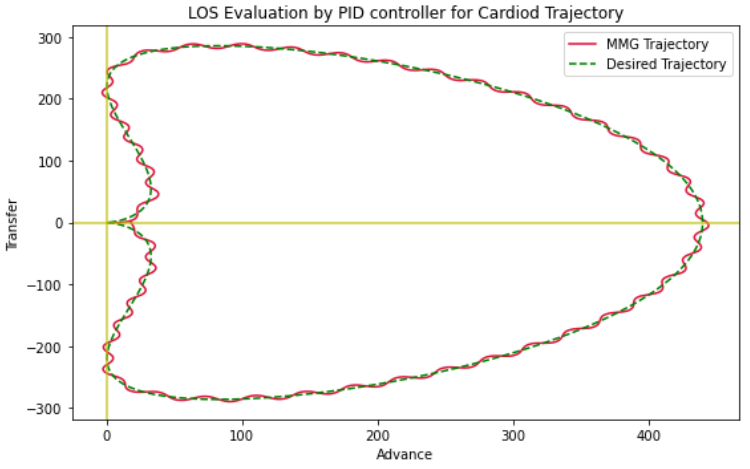


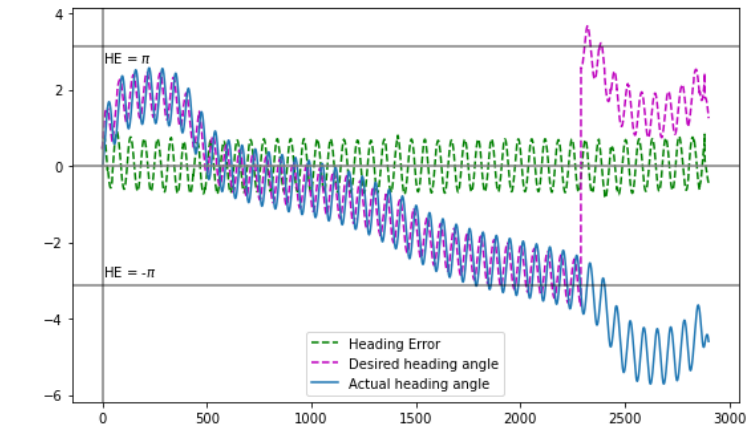
Cardioid Trajectory:





Parametric Curve:





Custom Points: