About

On a weekly meeting at Jan 9, 2023, the importance of plotting the velocity reference vector's parallel/orthogonal (to path) components as a function of normalized path error was discussed.

Drawing this curve will be the first step at utilizing the NLGL on a multicopter, by applying different velocity ramp-in profiles, which will result in more desirable behavior on the approach to path (which will also be parametrized; go straight to path fast, etc.)

Velocity Formulation

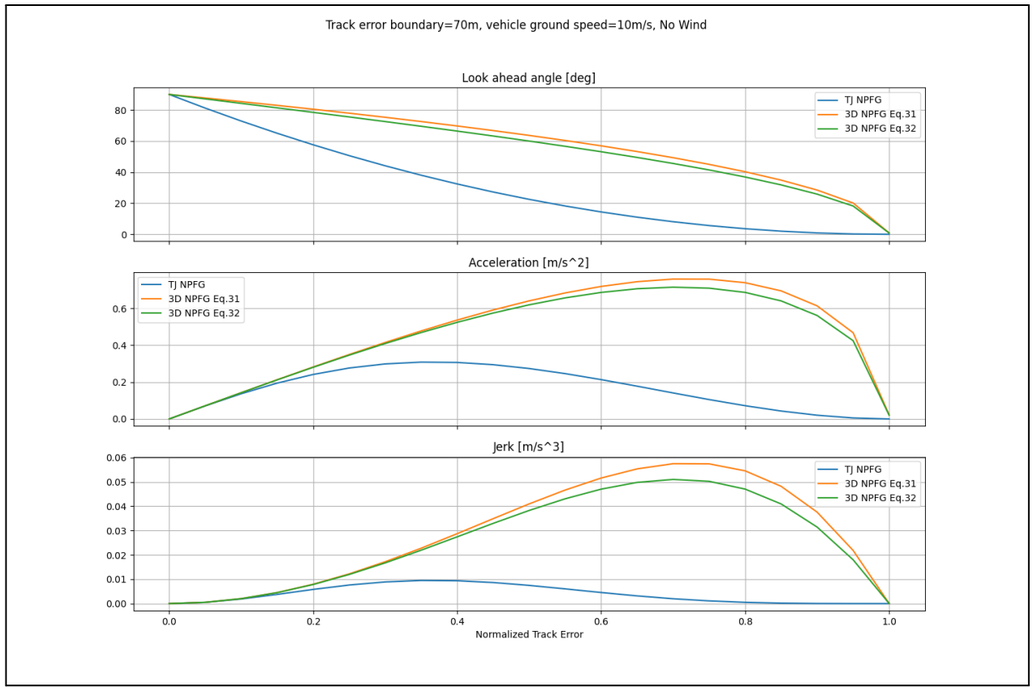
Goal: **Formulate a Velocity setpoint (Vector-Field), for each given track error variable** (indicating position error from the path)

- **In order to be sure that the VF around the path, when followed, doesn't exceed vehicle's velocity / maximum acceleration / maximum jerk constraints, knowing these parameters are crucial**
- In TJ's NPFG, the speed itself is capped by the 'nominal' and 'maximum' airspeed settings configured by the user
    - For maximum acceleration & jerk the current TJ's NPFG doesn't have a notion on this parameter

Questions

Is including Jerk/Acceleration limits really ok for the path following guidance?

As shown in Jan 9, 2023 's meeting note, the *pre-assumed (under no-wind & assuming vehicles is following the vector field exactly) acceleration & jerk embedded in the Vector Field can be drawn like so:



However, this is of course not 'intended', as the formulation didn't have any consideration for the acceleration & jerk (look-ahead angle is a simple quadratic function of normalized track error).

In some sense, having information about the vehicle's jerk/acceleration limits seems like an overlap with the lower-level controls (which executes tracking the air-velocity reference, respecting vehicle constraints).

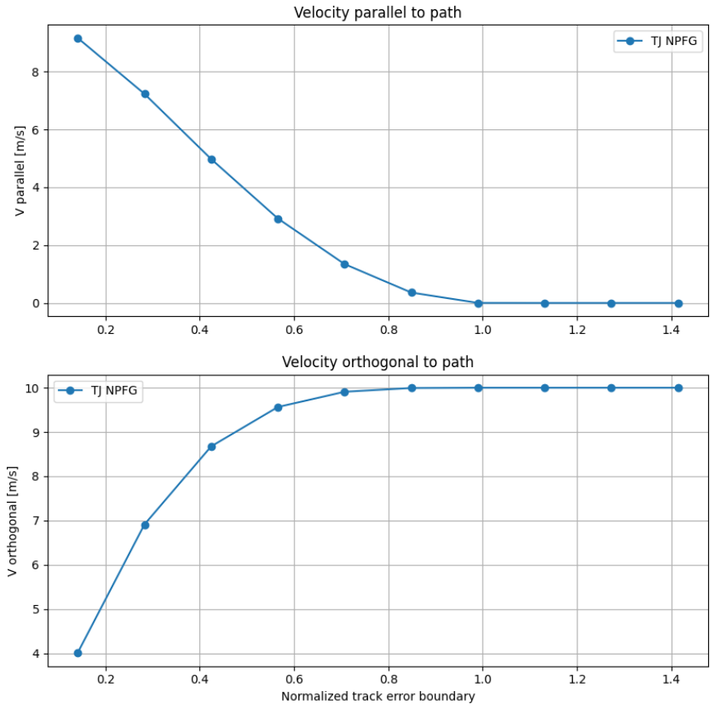
It seems this consideration comes from the fact that while TJ's NPFG relied on the 'look ahead angle' which always assumes that vehicle desires to move in the direction of the path (parallel) [which resulted in NPFG applied on Multicopter drawing an 'arc' while approaching the path], we are now breaking the velocity into parallel/orthogonal components in 'cartesian' coordinates relative to the path, and hence deducing the acceleration is way easier/intuitive (and jerk-limited trajectory becomes feasible).

Analysis on TJ NPFG's vehicle constraints and PF dynamics (period / damping / time constant / p-gain for lateral acceleration) is continued here: 2_Understanding TJ NPFG (Flying Backwards).

Visualizations

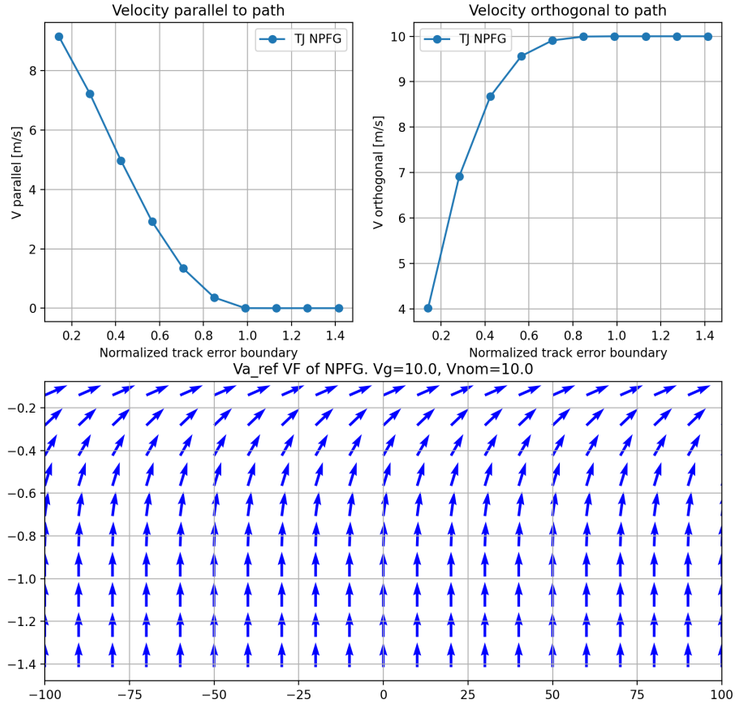
First Iteration - Jan 10, 2023

Done with this script.



Initial visualization of TJ's NPFG

Vehicle ground speed = 10m/s
Nominal speed = 10m/s



Visualization of the Curve & Vector Field of TJ's NPFG

Note: Only lower (y < 0) portion of the Vector Field is visualized, as the y > 0 is just a mirrored version.

Second Iteration - Jan 11, 2023

While analyzing TJ's NPFG's adaptive period boundary & internal calculations of time constants, etc, it occurred to me that the 'track error boundary' can not be set to a constant, and must be configurable depending on the PF model's characteristics (e.g. TJ's NPFG time constant gets calculated by NPFG Period & Damping ratio).

Therefore, on 2nd iteration, I am making these changes:

1. **Track error won't be normalized** by track error boundary, as the definition for the track error boundary isn't clear yet
2. **Vehicle's jerk, acc, vel constraints** will be considered

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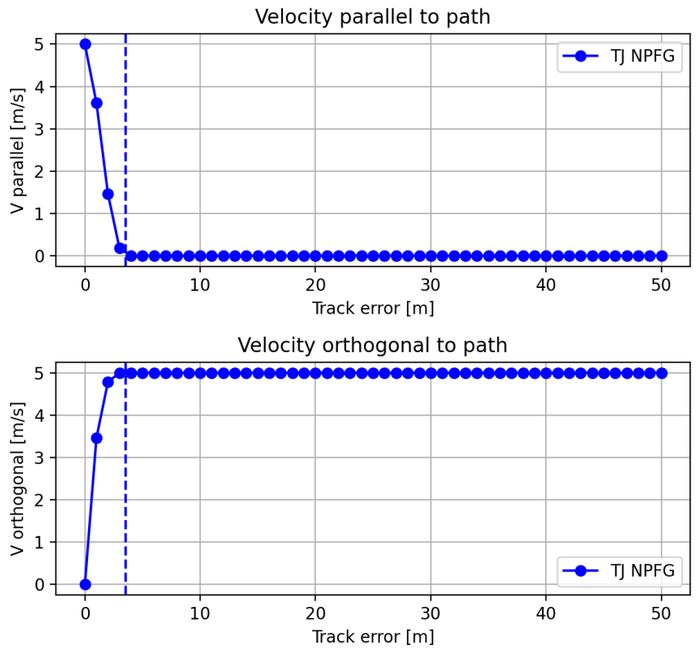
<td> 
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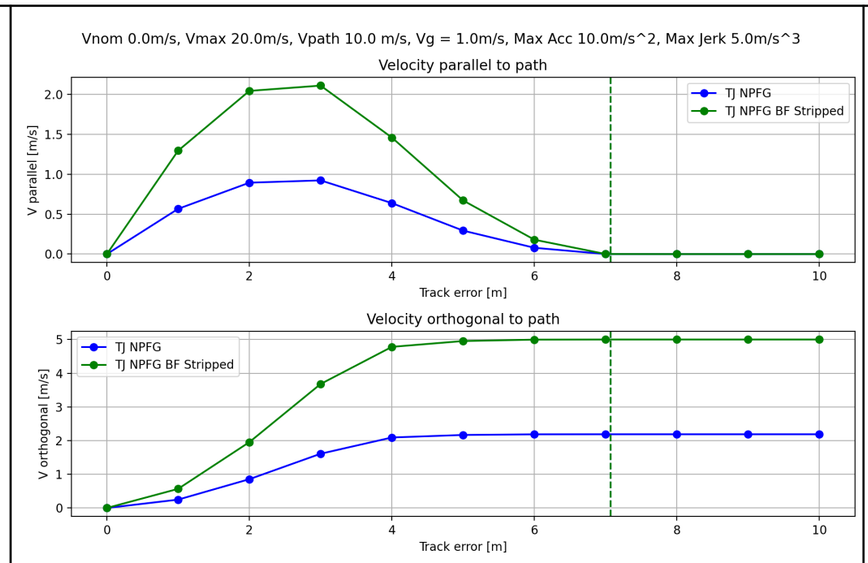
<td> 
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<tr>
<td>First iteration:</td>
<td>Initial success on differentiating the TJ NPFG vs with the one with bearing feasibility stripped.

Required:
- Setting user-set minimum ground-speed to 0.0 (this was overriding the min ground speed output of the track-keeping feature!)
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