Autonomous Perching Quadcopters
Time-to-Contact Guidance

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September 19, 2016

Time-to-Contact (Tau) Theory

- The idea is that animals guide themselves towards their target by closely monitoring the rate of closure of the relative distance between them [1].
- From the tried and tested $s = vt$:
- $\tau = \frac{\chi}{\dot{\chi}}$

where

$\tau \rightarrow$ time to contact

$\chi \rightarrow$ Spatial Gap

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Intrinsic Tau Guidance I

Constant $\dot{\tau}$ strategy

- $\dot{\tau} = k$ as a control goal to descend to a point.
- Leads to $\tau(t) = kt + \tau_0$
- from which we get a desired trajectory profile $\chi = \chi_0 \left(1 + k\frac{\chi_0}{\dot{\chi}_0} t\right)$

τ coupling strategy

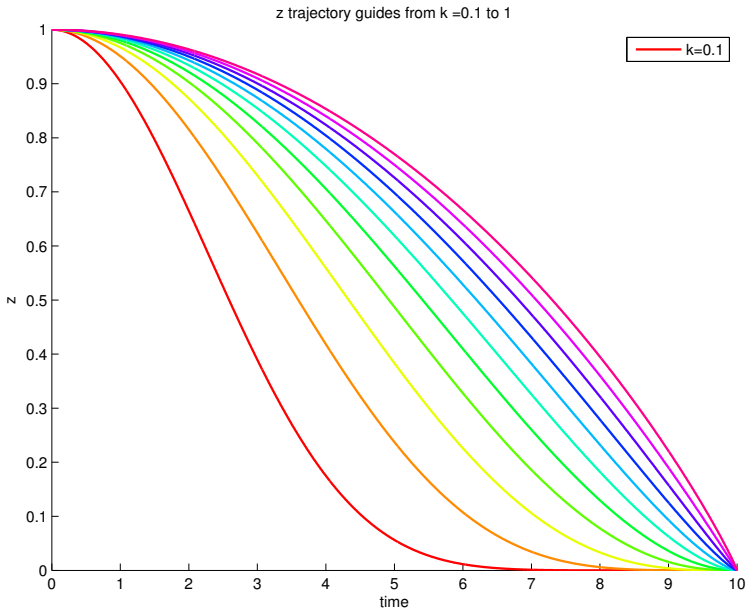
- Building on the above, it is possible to close multiple gaps(χ_x, χ_y) simultaneously by keeping their times to contact in a specific ratio $k_{x,y}$ such that $\tau_y = k_{x,y} k_x \tau_x$
- By adjusting $k_{x,y}$ to make the value of $k_y = k_{x,y} k_x$ smaller or larger, one can prioritize which gaps are closed first (useful for lining up to a target during the perch sequence)
- $y = Cx^{1/k_{x,y}}$ where $C = \frac{y_0}{x_0^{1/k_{x,y}}}$

Intrinsic Tau Guidance II

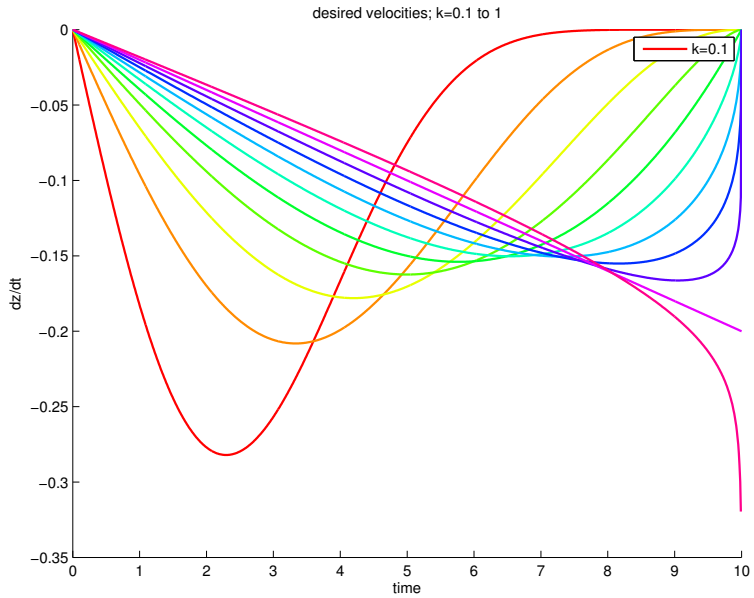
Intrinsic τ Guidance

- [1] postulates that organisms can generate a temporal guide (τ_g) based on how much time ahead of their current state they intend to reach their target.
- $\tau_g = \frac{k}{2}\left(t - \frac{t_f^2}{t}\right)$
- This leads to the following desired profile
  - $\chi = \frac{\chi_0}{t_f^{2/k}}\left(t_f^2 - t^2\right)^{1/k}$
    - which tends to be a skewed sigmoid curve
- Generally $k \in [0, 0.5)$ to reach the goal point with a zero velocity and acceleration

Intrinsic Tau Guidance III

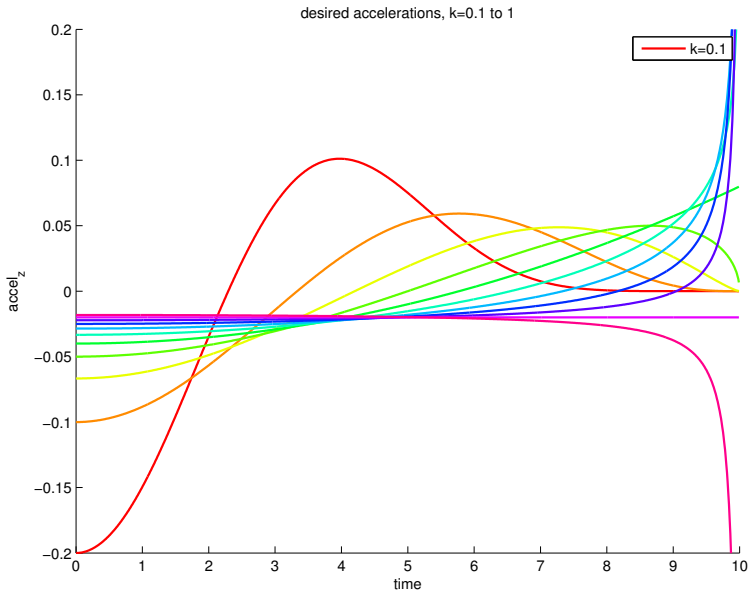


(a)



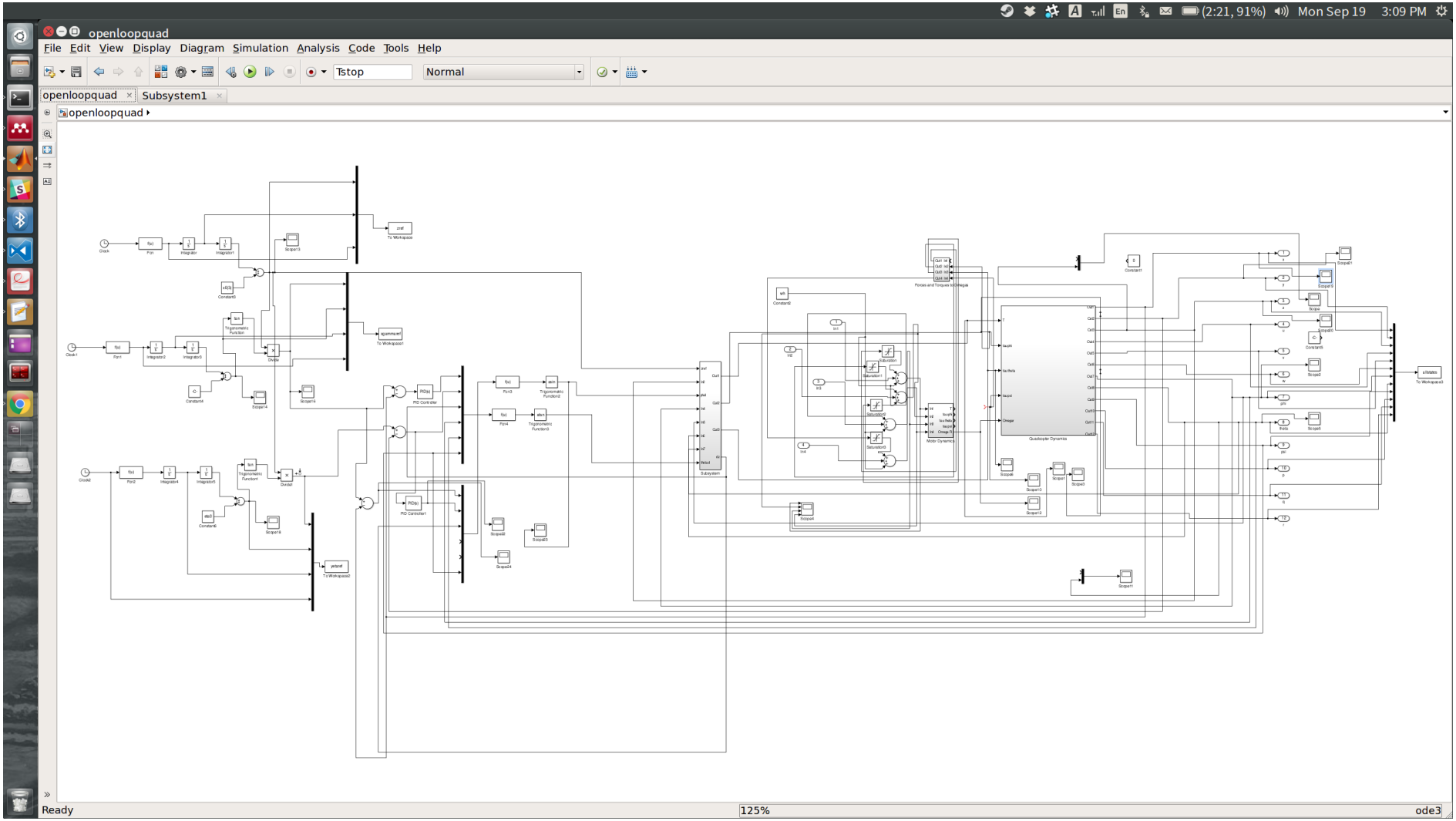
(b)

Intrinsic Tau Guidance IV

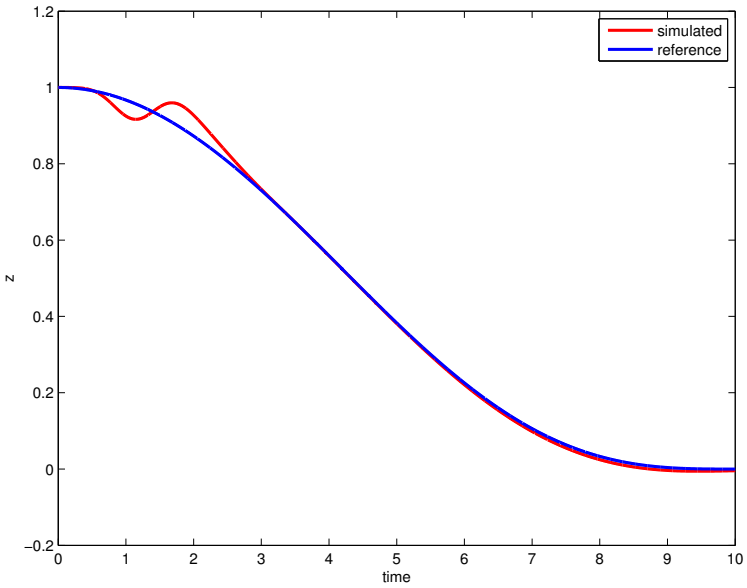


(c)

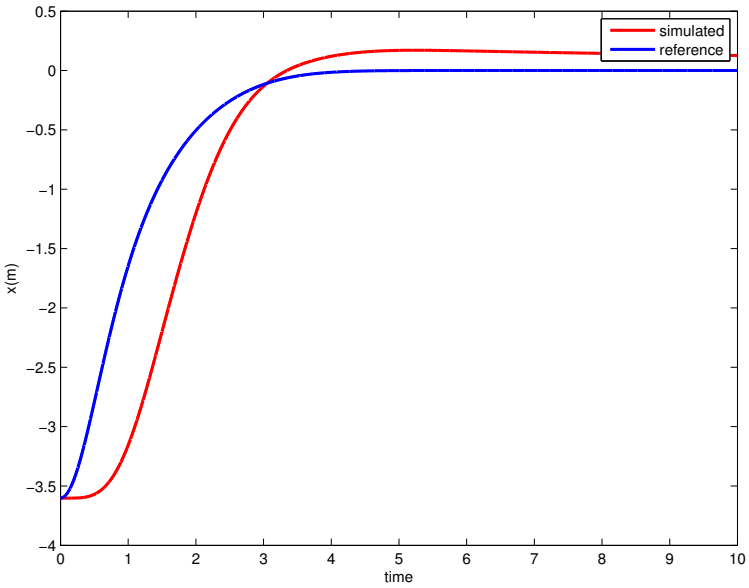
6DoF Simulations I



6DoF Simulations II



(d)



(e)

Remaining Work I

- ROS/SITL Simulations
- HITL/Experiments
- Camera intgration

References I

[1] David N. Lee. Guiding Movement by Coupling Taus. *Ecological Psychology*, 10(3-4):221–250, sep 1998.