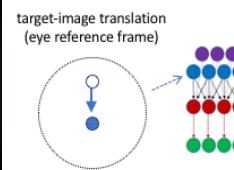




Sandia  
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# A Biologically-Inspired Algorithm for Interception



ICONS 2019

Frances S. Chance

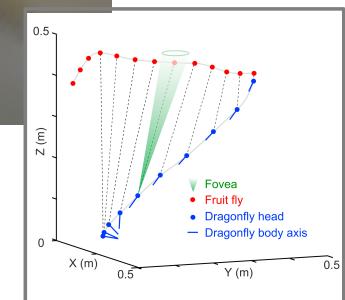
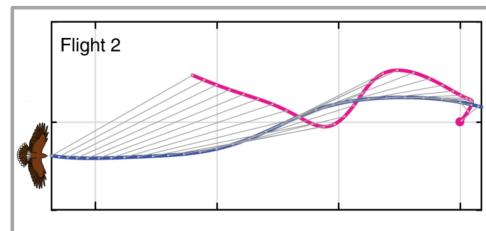


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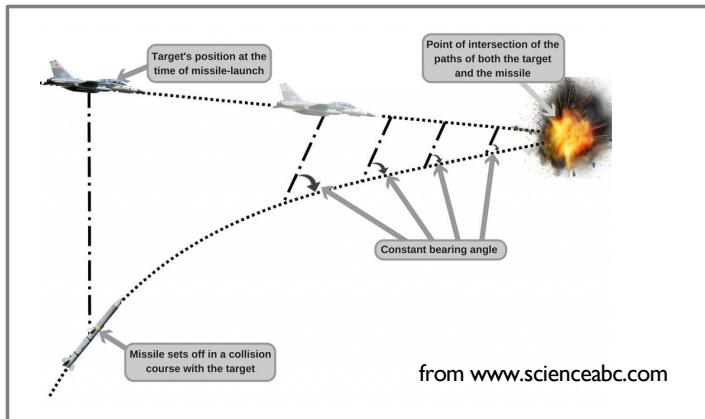


# Interception

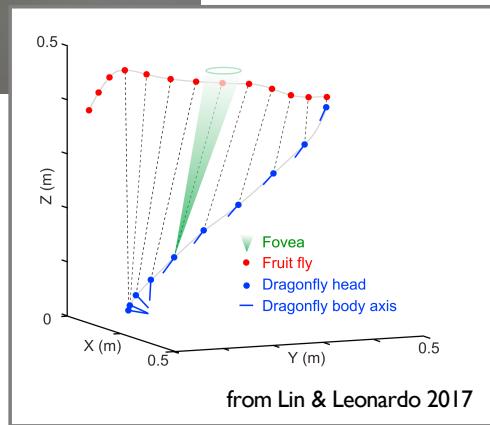
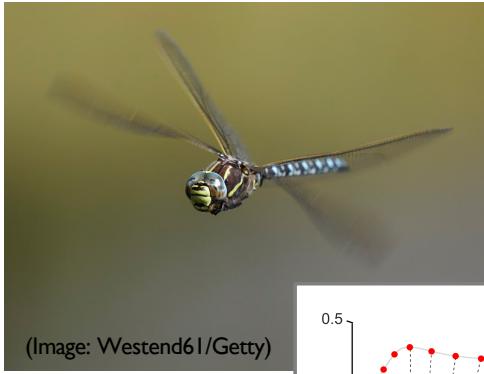
Common behavior in animals...



Still need solutions for man-made platforms...



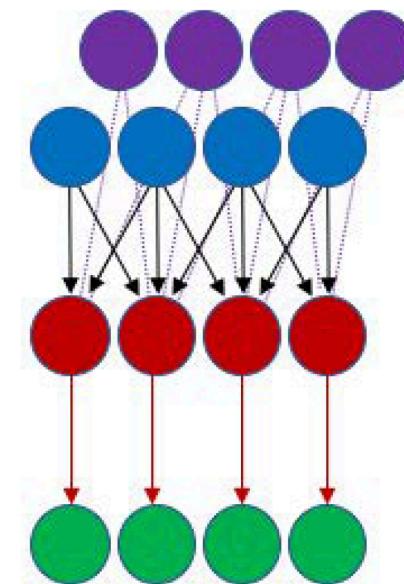
## Dragonflies as inspiration for an interception algorithm



- Dragonflies intercept prey when hunting
- Good at it (90-95% capture rate)

**Time scales of dragonfly interception computation  
is also very fast**

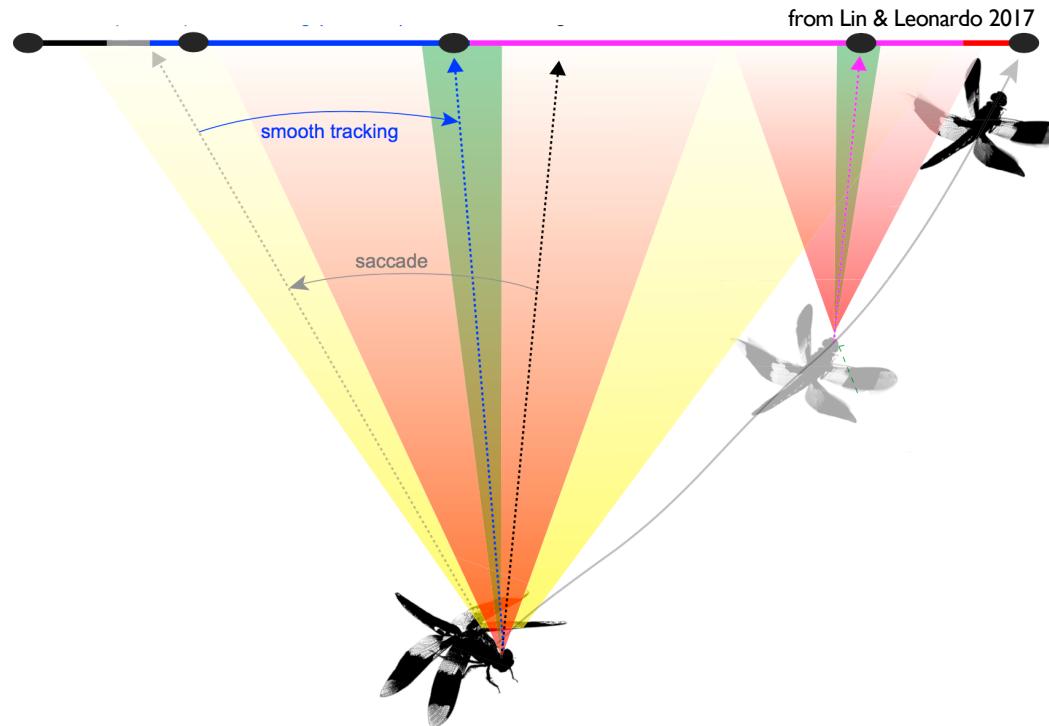
- Latency to react to prey steering: 50 ms



## Dragonflies as inspiration for an interception algorithm

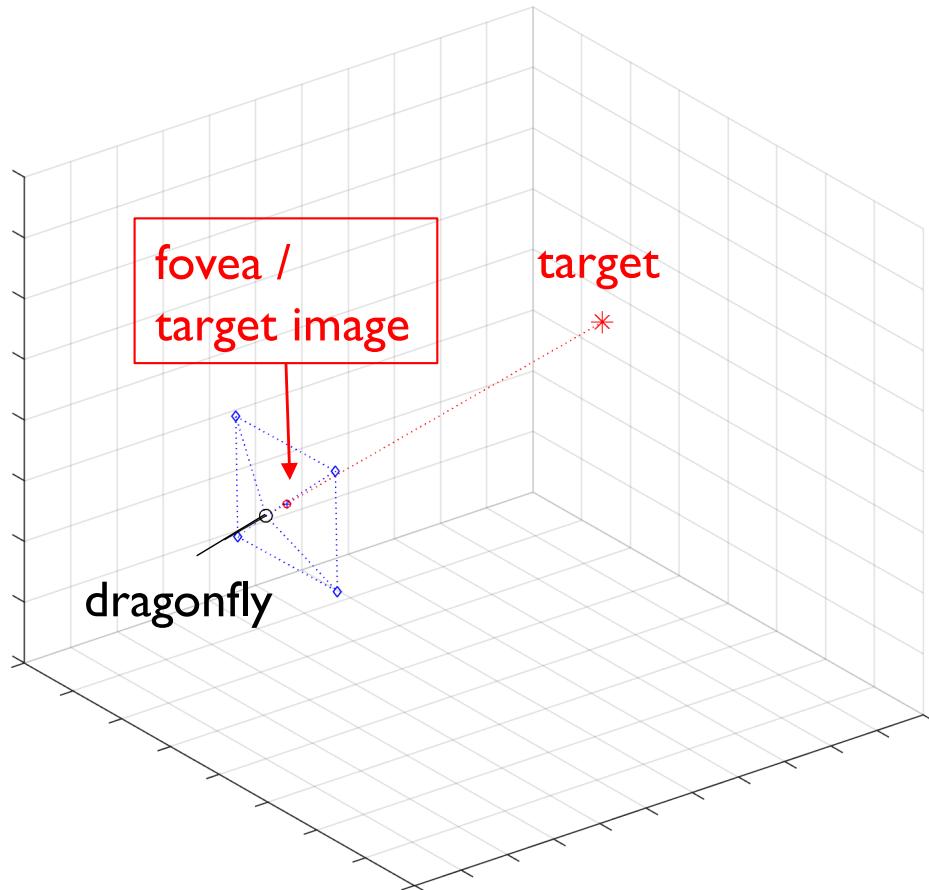


Is target-image slippage on eye enough information for a robust interception algorithm?



Dragonflies maintain prey at a particular eye-position (foveation) during approach

## Simulating a dragonfly

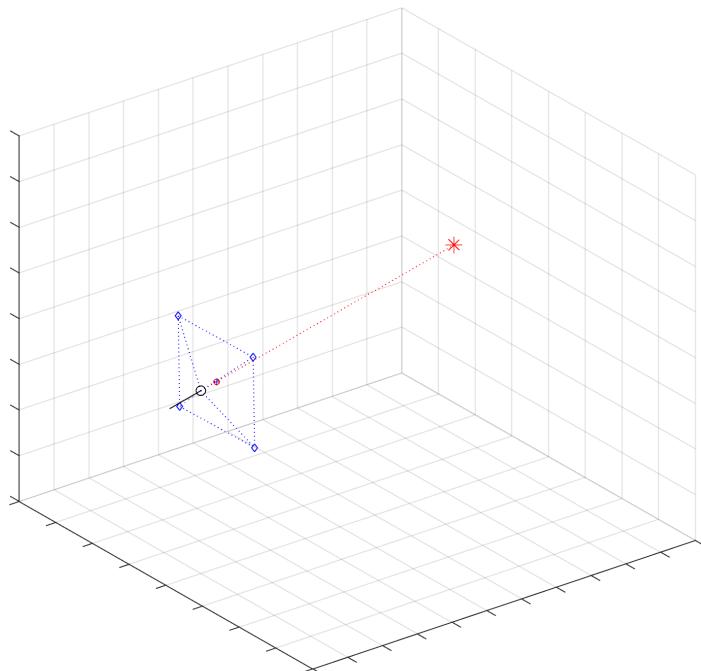


- dragonfly eye simulated as a 2D screen
- fovea at the center of the eye/screen
- dragonfly maneuvers to keep prey-image on fovea
- dragonfly and prey move at same maximum speed (unrealistic but more challenging)
- no restrictions on maneuverability

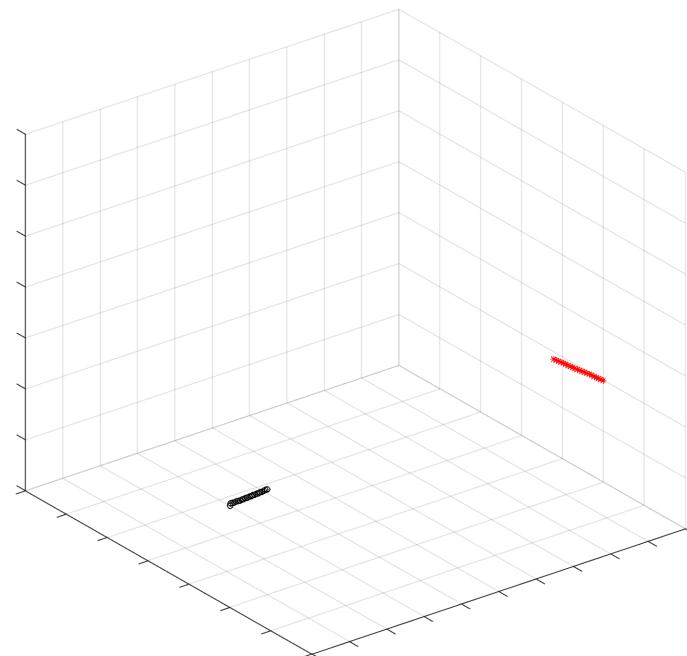
## Simulating a dragonfly



Dragonfly maneuvers to keep prey-image at eye-center (fovea)



dragonfly-centered reference frame

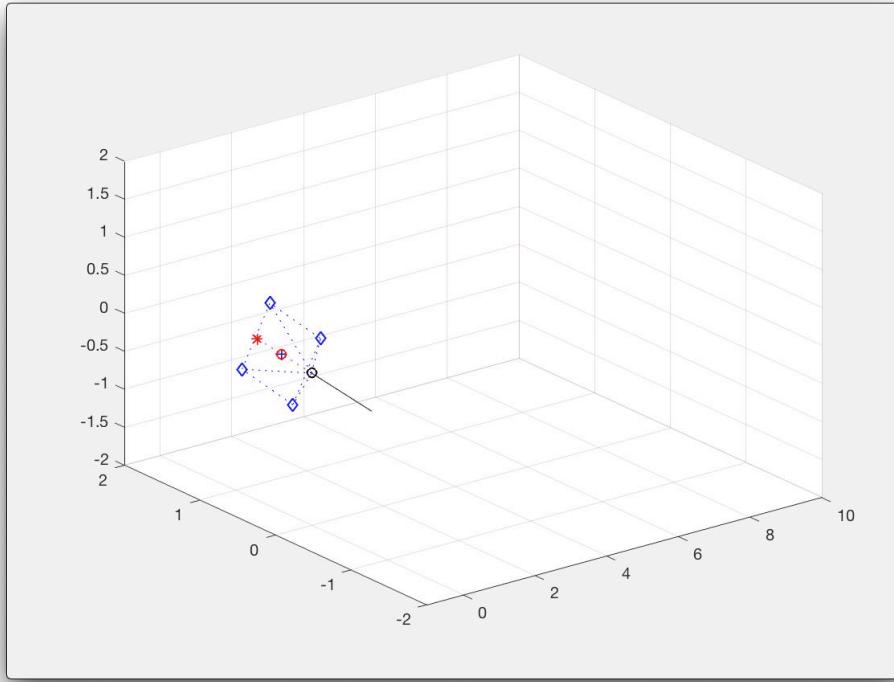


physical-space reference frame

# Simulating a dragonfly – target held at eye center

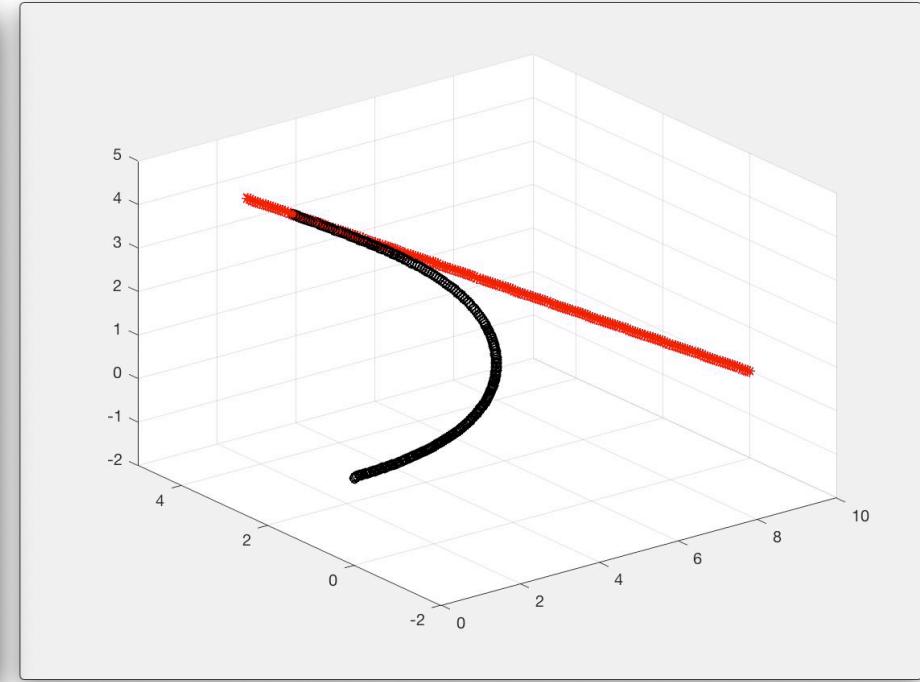


Dragonfly maneuvers to keep prey-image at eye-center (fovea)



dragonfly-centered reference frame

\*note: videos replaced by screenshot in PDF



physical-space reference frame

\*note: videos replaced by screenshot in PDF

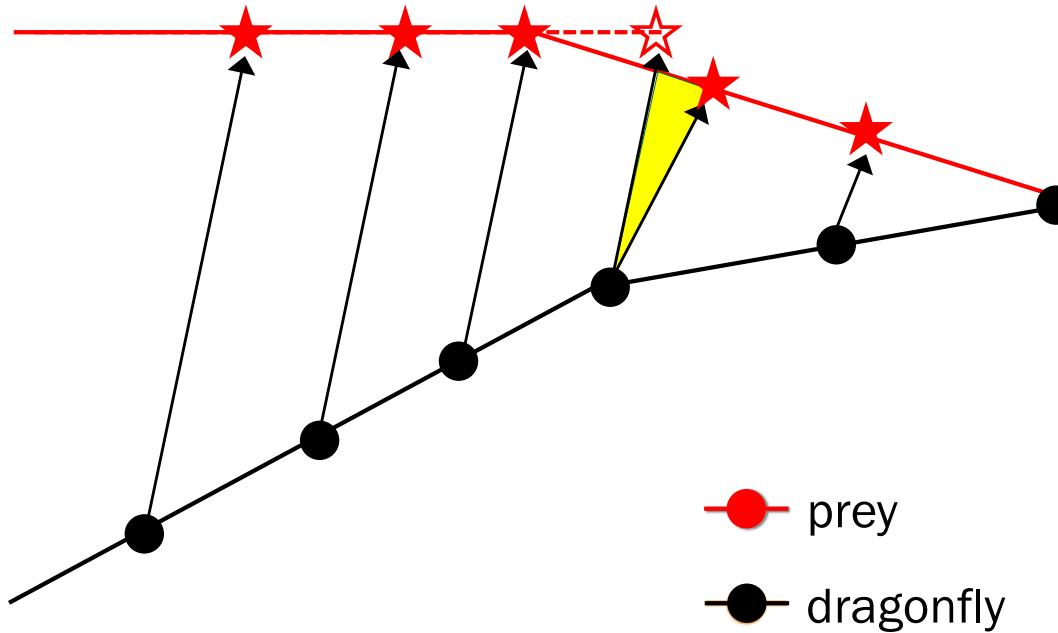
Classic pursuit behavior (dragonfly heads straight towards prey)

Viable interception strategy except without speed overmatch can fall into "endless pursuit"

## Proportional navigation



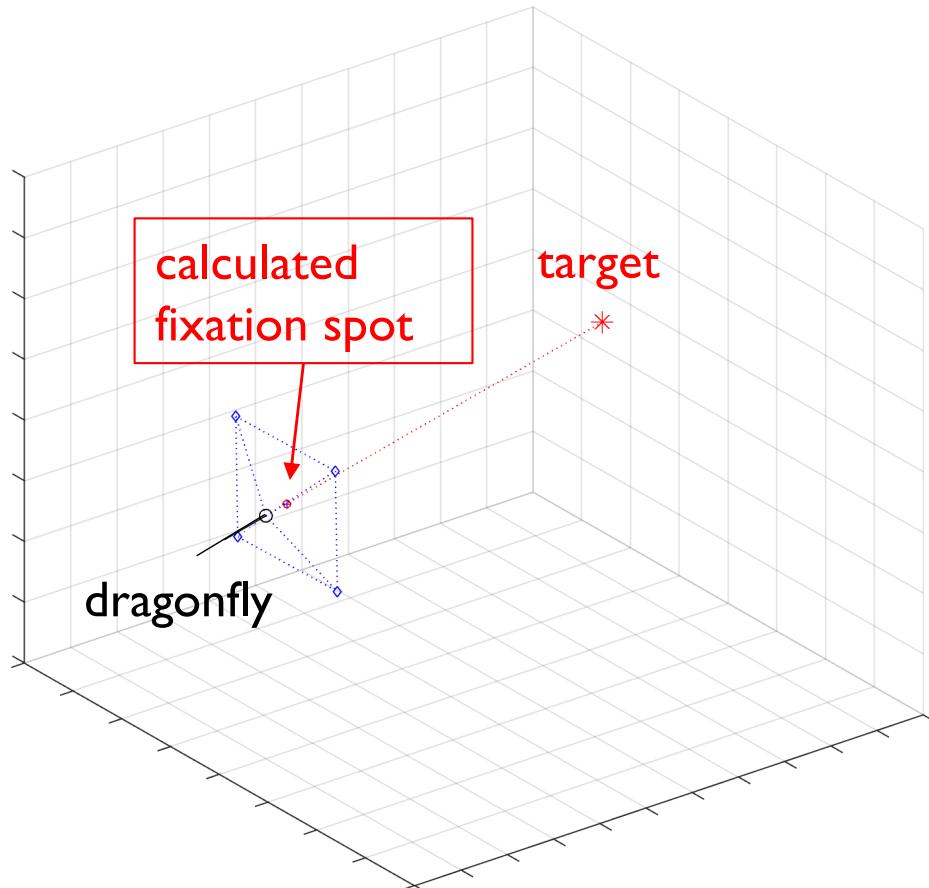
aka CBDR (constant-bearing decreasing-range) or parallel navigation



**Generates the geometrically shortest interception trajectory**

**Dragonflies use a form of proportional navigation to intercept their prey**

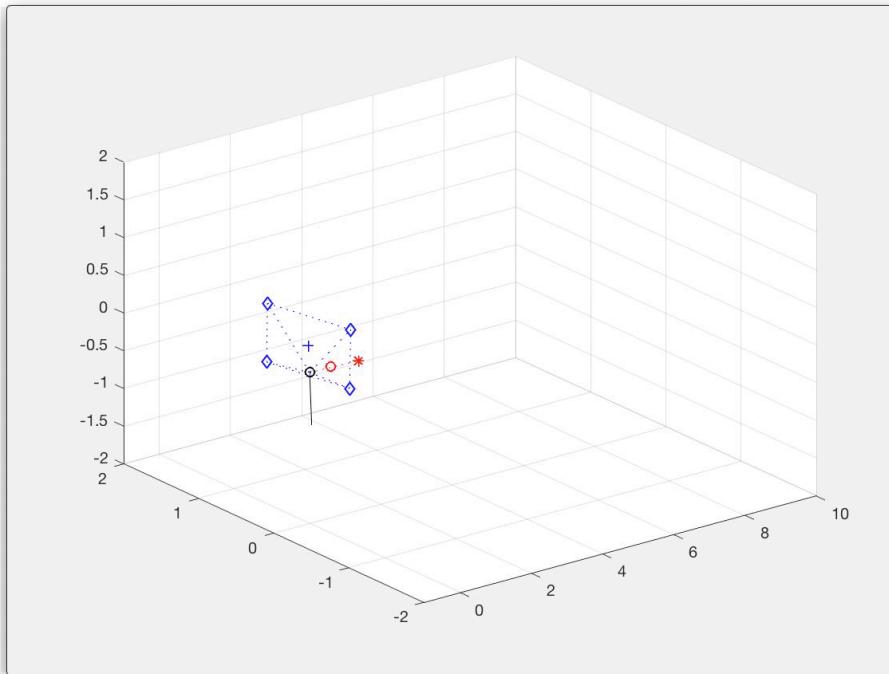
## Can proportional navigation be implemented using prey-image slippage on the eye?



- **correct “fixation spot” is calculated** based on the trajectory of the prey (relative to dragonfly trajectory)
- dragonfly maneuvers to keep prey-image on fixation spot
- dragonfly and prey move at same maximum speed (unrealistic but more challenging)

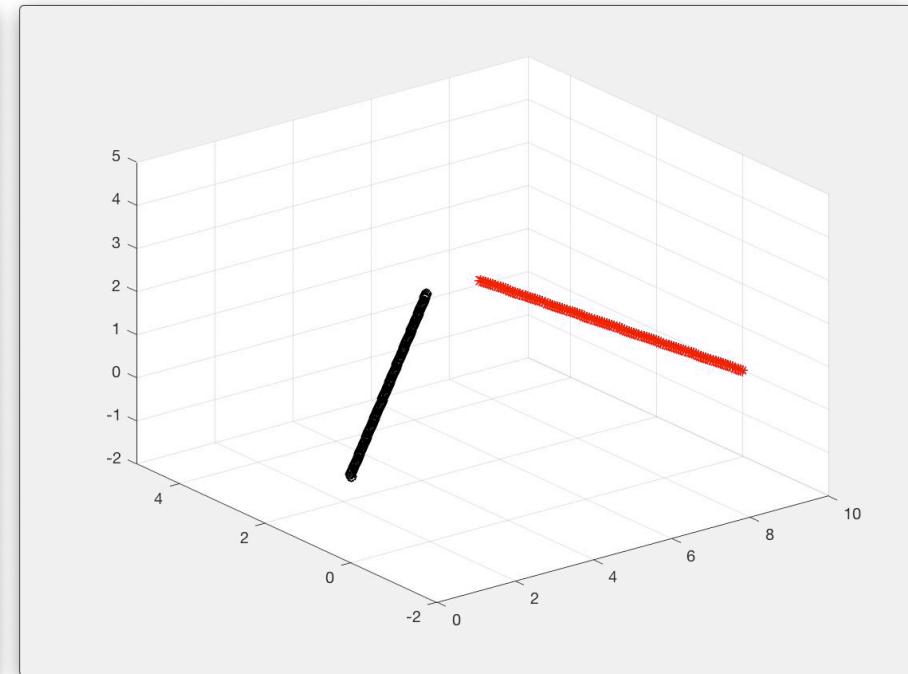
- 9 Can proportional navigation be implemented using prey-image slippage on the eye?

Dragonfly maneuvers to keep prey-image at fixation spot (calculated)



dragonfly-centered reference frame

\*note: videos replaced by screenshot in PDF



physical-space reference frame

\*note: videos replaced by screenshot in PDF

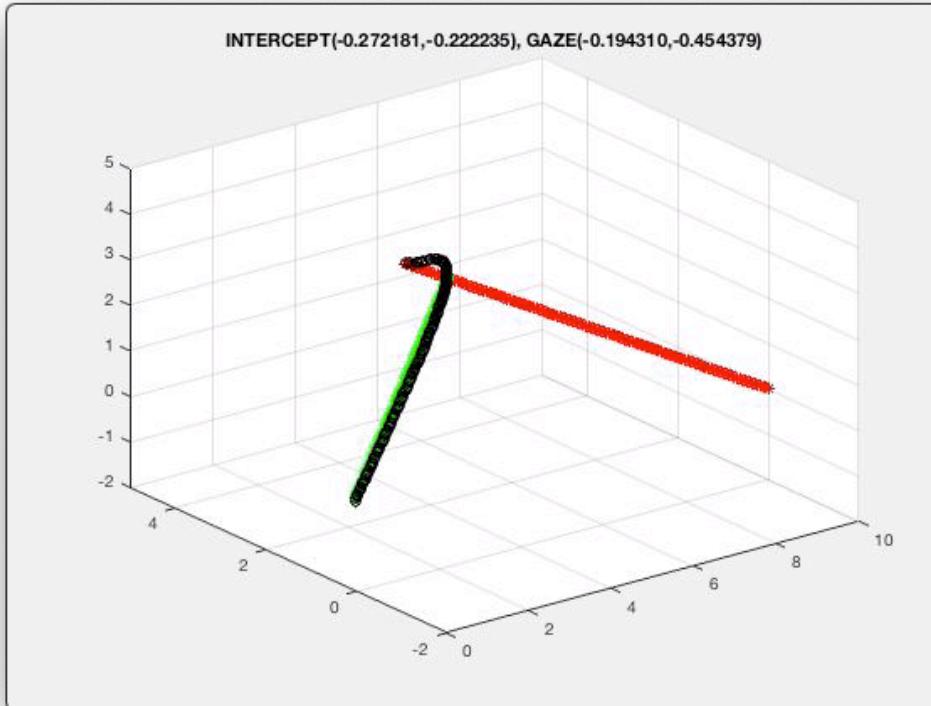
Potentially more robust strategy if prey has similar speed capabilities

However, vulnerable to rapid evasive prey maneuvering

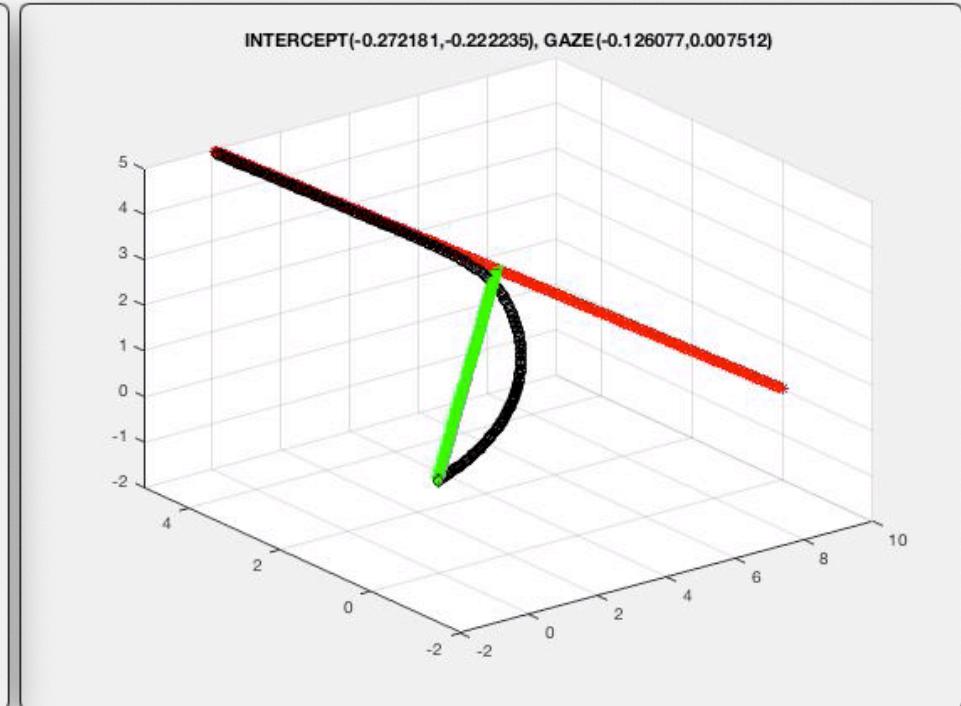


## What if the fixation spot isn't perfect?

Dragonfly maneuvers to keep prey-image at fixation spot (with noise added)



\*note: videos replaced by screenshot in PDF

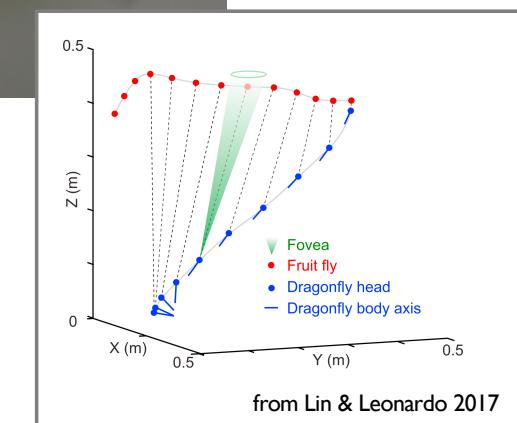
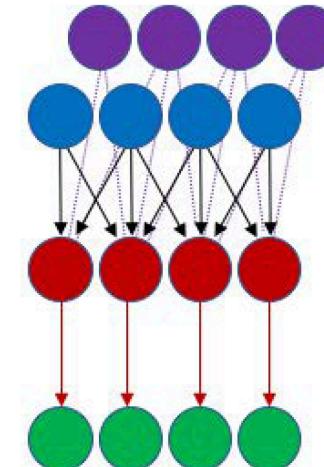


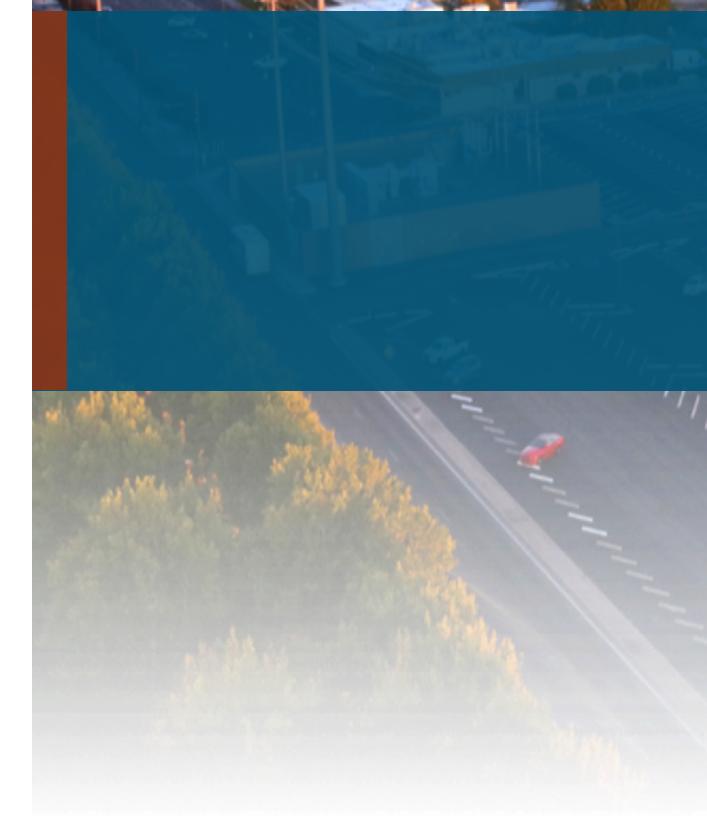
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Currently working on model for online adaptation of fixation spot  
(will be applicable for incomplete sensor information, evasive prey,  
error corrections)

## Summary

- Building a model of dragonfly-prey interception
- Focus on how dragonflies use visual input to calculate interception trajectories
- Dragonfly maneuvers to maintain prey-image on a particular fixation spot
  - Pursuit behavior if fixation spot is in center of eye
  - Proportional navigation if fixation spot is calculated based upon prey trajectory
- Ideal strategy may be some hybrid between pursuit and proportional navigation (if prey is evading)





# The End

Questions? Email [fschanc@sandia.gov](mailto:fschanc@sandia.gov)

