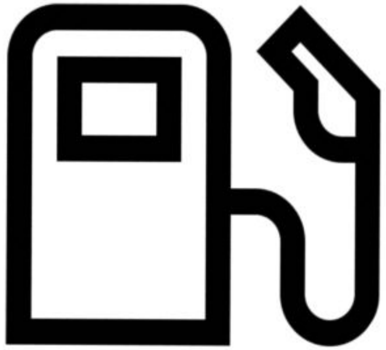
NASCAR Refueling Challenges:

The Strategy Behind a Pit Stop



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Outline

- Background
- Model Highlights
- Safety and Efficiency
- Proof Highlights
- Conclusion

Background

- NASCAR races
  - 36 total races
  - 34 oval tracks
  - .526 – 2.66 miles long
  - 188 – 500 laps
- Refueling rules
  - No sensors to monitor exact gas level
  - 24 gallons per pit stop

Model Highlights

- Controls
  - $if\ fuel > fc * v * T;\ continue;$
  - $if\ fuel \leq fc * v * T; fuel = max;$
- ODEs
  - $x' = v * dx$
  - $y' = v * dy$
  - $dx' = -dy$
  - $dy' = dx$
  - $fuel' = -fc * v$ (linear)
  - $fuel' = -(fc * v * t + c)$ (quadratic)

Safety and Efficiency

- Stay on track
  - $x^2 + y^2 = rad^2$
- Sufficient fuel
  - $fuel \geq 0$
- Do not stop unnecessarily
  - $if\ fuel > fc * v * T;\ continue;$

Proof Highlights (on track)

- Loop invariants
  - $x^2 + y^2 = rad^2$
  - $dx^2 + dy^2 = 1$
  - $dx * v = -y$
  - $dy * v = x$
  - $rad \geq 0$
- Differential Cuts
  - $dx * v = -y$
  - $dy * v = x$

Proof Highlights (sufficient fuel)

- Loop Invariants
  - $fc > 0$
  - $T > 0$
  - $fuelinit > fc * v * T$ (linear)
  - $fuelinit > fc * v * T^2 + c * T$ (quadratic)
  - $max > vc * v * T$
- Differential Cuts
  - $fuel = fuelinit - fc * v * T$ (linear)
  - $fuel = fuelinit - (fc * v * T^2 + c * T)$ (quadratic)

Conclusion

- Can CPS models help NASCAR teams?
  - Proof helps devise strategies
  - Use of algorithmic CPS controllers
- Future work
  - Acceleration/deceleration
  - Time constraints
  - Multiple cars
  - Tire degradation

Thanks!