**ProBLEM STATEmENT**

- Fast, appropriate reactions to smoke can be life-saving in fire emergencies
- Accurate visual assessment of how smoke is moving can provide vital information
- Unlike rigid objects, smoke and fluids change shape constantly; these dynamics can be informative [1] but can also create uncertainty as to the overall speed and direction of motion
- Prior work suggests that perception of global smoke motion may be unreliable and subject to systematic biases:
  - Speed tends to be underestimated when sensory uncertainty is increased [2,3]
  - Speed of threatening objects is overestimated [4]

**GOALS**

1. Identify potential motion cues in approaching smoke
2. Determine factors affecting perceived speed of approaching smoke

**Simulating Smoke**

- High resolution physics-based plumes of smoke moving towards an observer
- Smoke simulation based on fluid dynamics: Navier-Stokes solver with second-order semi-Lagrangian advection
- Wavelet noise applied to inflow velocities and smoke densities created turbulence

**Image Analysis**

- **Optic flow**: Local differential motion estimation [5]
- **Encircled Energy**: Radius defined by the number of pixels that encircle 50% of a frame’s intensity values

**Behavioral Study**

- Prediction-motion time-to-contact paradigm [6]
- N = 12; 240 trials
- Initial distance was varied

**Speed**

- Radial increase in speed from focus of expansion

**Expansion**

- Unlike for solid objects, the optic flow rate of expansion does not reliably indicate approaching smoke.
- Nonetheless, the size of approaching smoke increases consistently over time, providing a cue to approaching motion.
- This cue differs depending on smoke density.

**Discussion**

- Optical flow expansion and size change are not necessarily correlated motion cues in smoke [7]
- A systematic bias in perceived time-to-contact is consistent with size change information
- Fire evacuation models may be improved by considering perceptual features of smoke [8]

**References**

11. Attention, Perception, & Psychophysics, 57(2), 231-245.