Historically, visual data from fires has been limited to 2D, often with a narrow field of view and for limited periods of time; e.g., if the camera is destroyed.
360-Degree Video in Fire Research

High-resolution omni-directional cameras are rapidly getting smaller, better and cheaper.

GoPro OMNI (launched 2016)
- 120 mm³
- 2.7K res
- $4000

GoPro Fusion (launched 2017)
- 75 mm tall
- 5.2K res
- < $600

360-degree image of cross-laminated timber compartment taken using GoPro OMNI Sync Cube at the National Fire Research Laboratory in 2017

360-Degree Video in Fire Research

For video in fire, the challenge is twofold: keep the camera cool and filter the intense thermal radiation.

- Gas temperatures to 1400 °C
- Thermal radiation > 100 kW/m²

Hoehler, M; Su, J; Bundy, M. Dataset from Fire Safety Challenges of Tall Wood Buildings - Phase 2: Task 3 - Cross Laminated Timber Compartment Fire Tests [https://doi.org/10.18434/T4/192252]
Water is extremely good at absorbing thermal radiation...

...while transmitting energy in the visible spectrum.

Energy intensity spectrum for a hydrocarbon fire

Relative transmittance through water for 31 mm path length

Bandpass in visible spectrum
360-Degree Video in Fire Research

NIST has exploited this fact to get 2D video cameras closer to fires

Version 1.0 (2016)
Credit: M. Hoehler/NIST

Version 2.2 (2017)

Video camera live streaming in 1080p
Version 3.0 (2018)

360-Degree Video in Fire Research
Concept sketch of application to 360-degree cameras

Credit: N. Hanacek/NIST
360-Degree Video in Fire Research
Burn Observation Bubble (BOB) functional prototype version 1.0

Credit: M. Hoehler/NIST
360-Degree Video in Fire Research

Case Study 1: Influence of Fire on the Lateral Resistance of Cold-Formed Steel Shear Walls – Kitchen Fire

Hoehler, M; Andres, B; Bundy, M; Influence of Fire on the Lateral Resistance of Cold-Formed Steel Shear Walls – Phase 2: Oriented Strand Board, Strap Braced, and Gypsum-Sheet Steel Composite, Technical Note (NIST TN) – 2038 (https://doi.org/10.6028/NIST.TN.2038)

Camera located in front of the doorway

Credits: M. Hoehler/NIST
360-Degree Video in Fire Research
Case Study 1: Influence of Fire on the Lateral Resistance of Cold-Formed Steel Shear Walls – Kitchen Fire

Learnings:
• Combustible seal failed
• Bolts stretched too much
• Water flow rate too low
• Camera exposure saturated
• Need audio
360-Degree Video in Fire Research
Case Study 2: Smithsonian Institution – Preparedness and Response in Collections Emergency (PRICE) Workshop

Stereo sound was added using two external microphones
360-Degree Video in Fire Research

Inexpensive capsule mics were installed in the compartment wall with thermal protection.

Audio recording setup

Credits: M. Hoehler/NIST

360-Degree Video in Fire Research

Case Study 2: Smithsonian Institution – Preparedness and Response in Collections Emergency (PRICE) Workshop

Credits: M. Hoehler/NIST
360-Degree Video in Fire Research
Case Study 3: Prescribed forest management fires in the New Jersey Pine Barrens

\[ A = 4 \cdot \pi \cdot r^2 \quad r = 80 \text{ mm} \]

\[ c_{H_2O} = 4.186 \text{ joule/gram} \ C^{\circ} \]

\[ \Delta T = 20 \ C^{\circ} \quad \text{Allowable temperature rise of camera} \]

Assumed duration and intensity of max heat flux

\[ t = 10 \text{ min} \quad \dot{q} = 100 \ kW/m^2 \]

\[ \text{mass}_{H_2O} = \frac{Q}{c_{H_2O} \cdot \Delta T} = 57 \text{ kg (} \approx 15 \text{ gal water)} \]

Where, \[ Q = \dot{q} \cdot A \cdot t \]
360-Degree Video in Fire Research

Case Study 3: Prescribed forest management fires in the New Jersey Pine Barrens

A first step from 360-degree video to Augmented Reality (AR) was achieved using a commercially-available game engine.

Once the video is transcoded into the game engine, one can add interactive elements to augment the user experience:

- data overlays
- explanatory information
- ...
360-Degree Video in Fire Research

360 fire video was successfully displayed in various immersive viewing environments.

NIST’s 3D visualization laboratory

Viewing in the SunCAVE at the UC San Diego Qualcomm Institute

Credit: F. Kuester/UCSD

360-Degree Video in Fire Research

Special thanks to Arron Kirchoff & Jeffrey Anderson (Master Glassblowers), Falko Kuester (UCSD/Calit2 Professor for Visualization and Virtual Reality), NIST Shops, William (Tre) Harrison, David Stewart, Norris Ng