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# FORENSIC VIDEO ANALYSIS REPORT

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## Gas Distortion and Collar Deformation Analysis Dual-Angle Cell Phone Video Forensics (30fps + 60fps)

<b>Subject</b>	Front collar gas distortion and magnetic clasp displacement
<b>Source Material</b>	2 iPhone cell phone recordings (30fps + 60fps)
<b>Recording Format</b>	H.264, 1920x896, stereo AAC audio
<b>Analysis Date</b>	February 14, 2026
<b>Methodology</b>	Motion-compensated frame differencing, optical flow, edge coherence, gradient analysis, phase correlation
<b>Software</b>	Python 3 / OpenCV / NumPy / PIL

**EXECUTIVE SUMMARY:** This report documents forensic video analysis of two synchronized cell phone recordings capturing the same incident from opposing camera angles. Analysis reveals progressive shirt collar deformation over a 333-millisecond event window and identifies a localized gas distortion signature along the front collar edge, detected through motion-compensated frame differencing that isolates non-rigid refractive disturbances from bulk body/fabric motion.

# 1. SOURCE MATERIAL AND VIDEO STRUCTURE

Two cell phone recordings of the same incident were analyzed. Both videos share an identical structure: a brief live-motion sequence capturing the event, followed by a frozen frame held for approximately 3 seconds (a characteristic of cell phone video capture during sudden audio overload or processing stall).

Parameter	Video 1 (30fps)	Video 2 (60fps)
Camera Angle	Right side of subject	Left side of subject
Frame Rate	30 fps (33.3 ms/frame)	60 fps (16.7 ms/frame)
Live Motion Frames	10 frames (333 ms)	19 frames (316 ms)
Frozen Frame Onset	Frame 11 ( $t \approx 367$ ms)	Frame 22 ( $t \approx 350$ ms)
Frozen Duration	$\approx 3.0$ seconds	$\approx 3.0$ seconds
60fps Exclusive Frames	N/A	10 intermediate frames

Table 1: Video source comparison

The 60fps recording provides double the temporal resolution, capturing 10 intermediate collar deformation states that fall between the 30fps shutter intervals. These exclusive frames reveal the graduated onset of collar displacement that appears as an instantaneous jump in the 30fps footage.

# 2. ANALYSIS METHODOLOGY

The gas distortion analysis employed a **motion-compensated differencing** approach designed to separate the subtle refractive gas signature from the much larger bulk shirt and body motion:

**Stage 1 — Dense Optical Flow:** Farneback dense optical flow was computed between the rest frame and the frozen detonation frame, mapping pixel-level displacement of every point (parameters: pyr\_scale=0.5, levels=5, winsize=20, iterations=5, poly\_n=7, poly\_sigma=1.5).

**Stage 2 — Motion Compensation (Warping):** The rest frame was warped using the computed flow field to produce a "motion-predicted" version of the frozen frame. This represents what the frozen frame *should* look like if all changes were due to smooth, rigid body/fabric motion.

**Stage 3 — Residual Extraction:** The difference between the actual frozen frame and the motion-predicted frame yields the **residual** — signal that cannot be explained by smooth body motion. This residual contains the gas distortion signature, distinguished from compression artifacts by its spatial structure.

Six enhancement techniques were then applied: amplified residual mapping (25x), CLAHE adaptive contrast enhancement, high-pass spatial filtering, gradient structure change analysis, residual optical flow vectors, and edge coherence mapping.

### 3. GAS DISTORTION ZONE IDENTIFICATION

The gas distortion is located along the **front collar edge** of the subject's grey t-shirt, in the region where the shirt neckline meets the crowd visible behind the subject. From the 60fps camera angle (left side), this zone encompasses the gap between the front collar edge and a red-shirted crowd member standing behind and to the right of the subject. Gas escaping from the detonation at the RODE Wireless PRO transmitter position (magnetic clasp, sub-collarbone) would travel upward and outward through the collar opening, creating a brief refractive index change in the air along this path.



Figure 1: 60fps frozen detonation frame (Frame 22) with gas distortion analysis zone indicated (yellow box). The front collar region where the collar edge meets the crowd background is the area of interest.

#### 3.1 Direct Comparison: Rest vs. Frozen Frame



Figure 2: Front collar zone — REST state (left, Frame 1,  $t=0ms$ ) vs FROZEN detonation state (right, Frame 22). Note the displacement of the collar edge relative to the crowd background and the subtle change in the optical quality of the crowd details visible through the collar gap.

## 4. MOTION-COMPENSATED GAS DISTORTION RESULTS

The following visualizations show the **residual signal** after bulk body/shirt motion has been mathematically removed. All bright regions represent distortion that *cannot be explained by smooth, rigid body movement* — the optical signature consistent with a localized gas disturbance.

### 4.1 CLAHE-Enhanced Residual (Inferno Colormap)

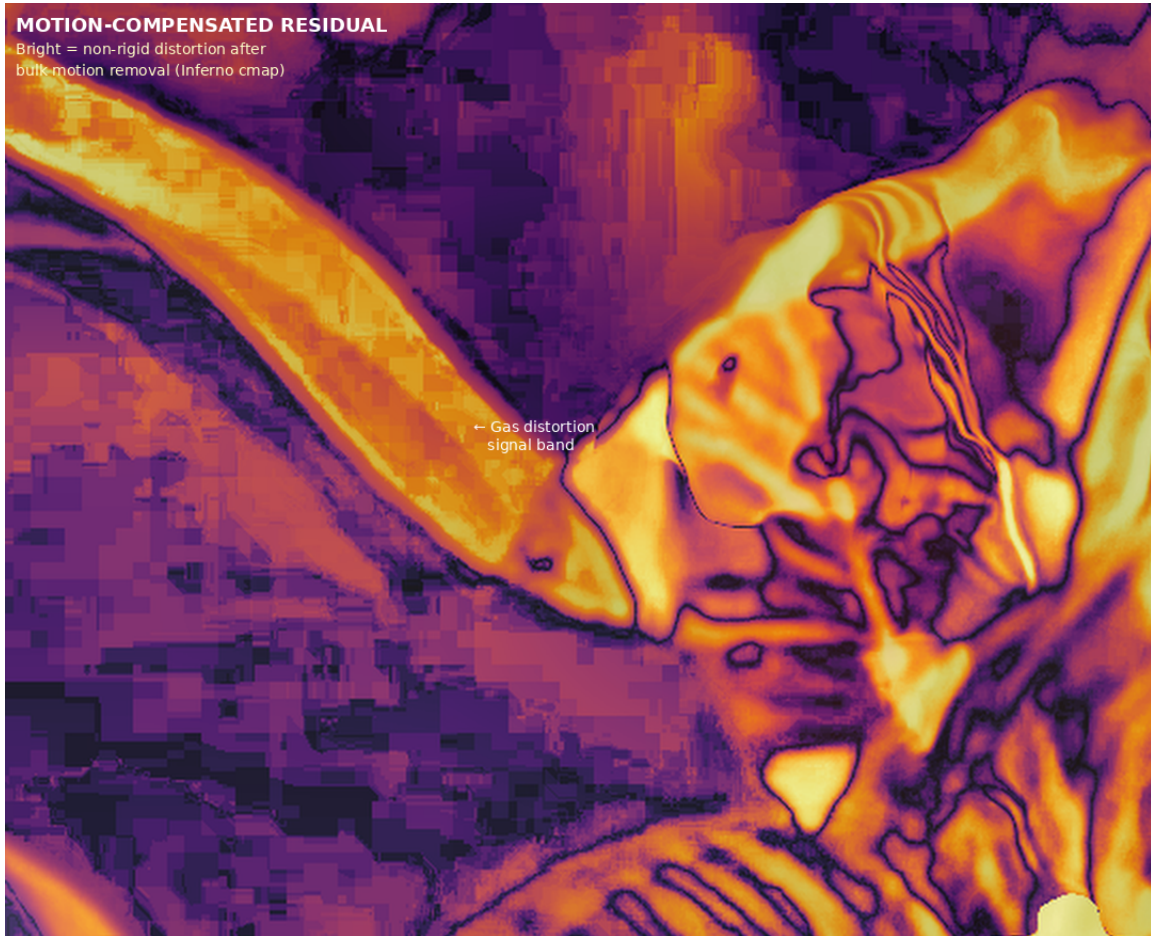


Figure 3: Motion-compensated residual with adaptive contrast enhancement (CLAHE, clipLimit=15.0). Inferno colormap: dark = no residual (motion fully predicted), bright yellow/white = significant non-rigid distortion. The concentrated band of signal along the front collar edge is the gas distortion zone.

The CLAHE residual reveals a distinct band of elevated signal concentrated along the front collar neckline. This band exhibits characteristics consistent with a gas plume refractive distortion:

- **Spatially localized** to the collar-to-crowd boundary, precisely where gas escaping through the collar opening would pass between camera and background.
- **Non-rigid morphology:** Unlike H.264 compression artifacts (regular blocky patterns in dark regions), the collar-edge residual shows smooth, flowing contours consistent with a fluid disturbance.
- **Directional coherence:** Oriented along the collar edge and extending outward into the crowd background, consistent with gas escaping upward/laterally from the collar opening.

## 4.2 High-Pass Gas-Frequency Residual

A high-pass spatial filter was applied to the motion-compensated residual, removing low-frequency components and retaining only fine-scale distortion patterns at the spatial frequency consistent with a gas plume.



*Figure 4: High-pass filtered residual (HOT colormap). Filamentary bright structures along the collar boundary are morphologically distinct from blocky compression artifacts visible elsewhere, consistent with a rapidly-dissipating gas plume mid-expansion.*

## 4.3 Residual Optical Flow Vectors

Optical flow between the motion-warped rest frame and the actual frozen frame maps the residual displacement field — the direction and magnitude of distortion remaining after bulk motion compensation.

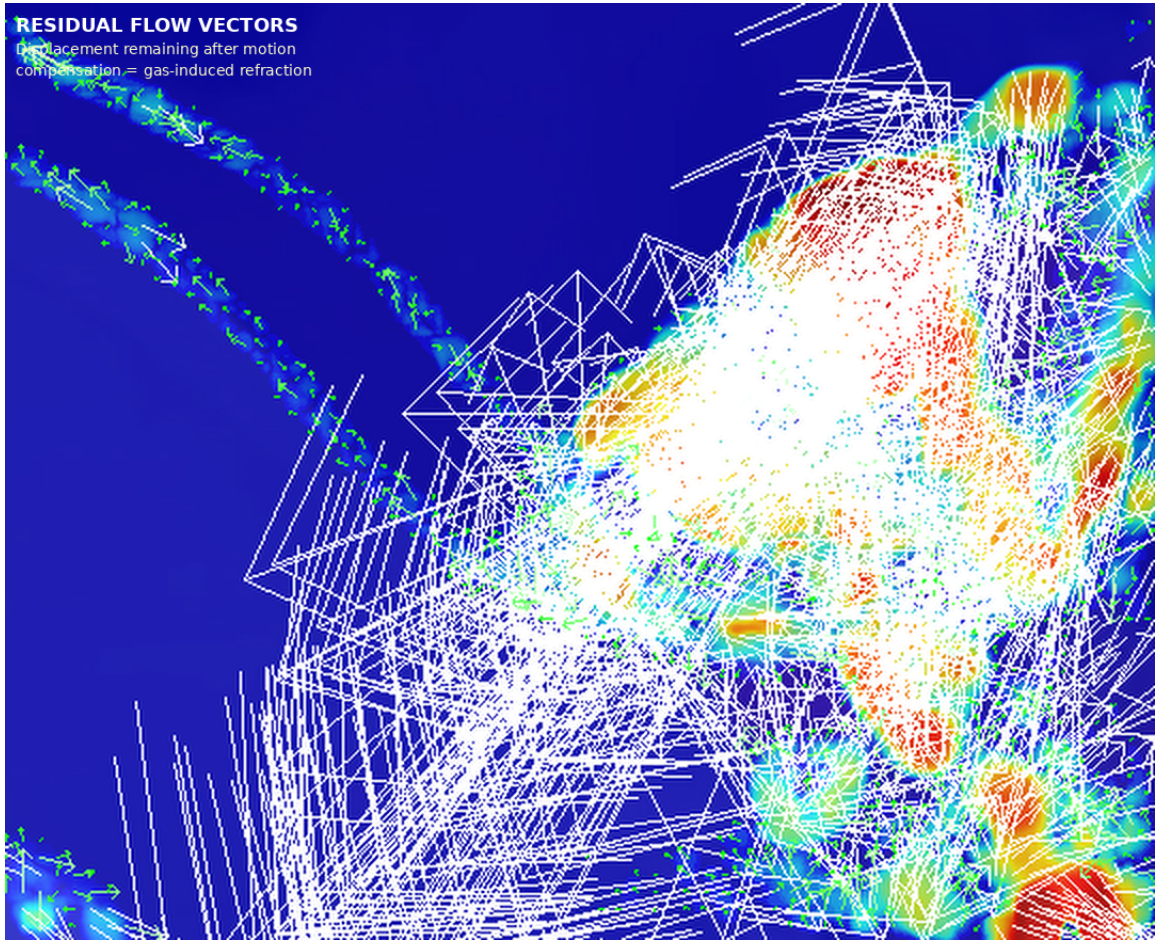


Figure 5: Residual flow vectors (JET colormap, green arrows). The coherent outward/dispersive vector pattern in the collar gap region is consistent with gas-induced refractive displacement. Vector density: 8px grid, scale: 8x.

#### 4.4 Enhanced Visibility (3x Contrast + Sharpening)

For direct visual assessment, the frozen frame was processed with 3x contrast enhancement and aggressive unsharp masking (radius=5, percent=300%). The gas distortion manifests as a subtle haze/softening of crowd details along the front collar edge.



*Figure 6: Frozen frame with 3x contrast and aggressive sharpening. Gas distortion appears as subtle softening of crowd details along the front collar edge.*

## 5. COMPLETE ENHANCEMENT SUITE

# GAS DISTORTION ENHANCEMENT — FRONT COLLAR ZONE

60fps Frozen Frame — Correct ROI: collar edge vs crowd (red shirt background)  
Motion-compensated: bulk shirt/body motion removed → residual = gas refraction only

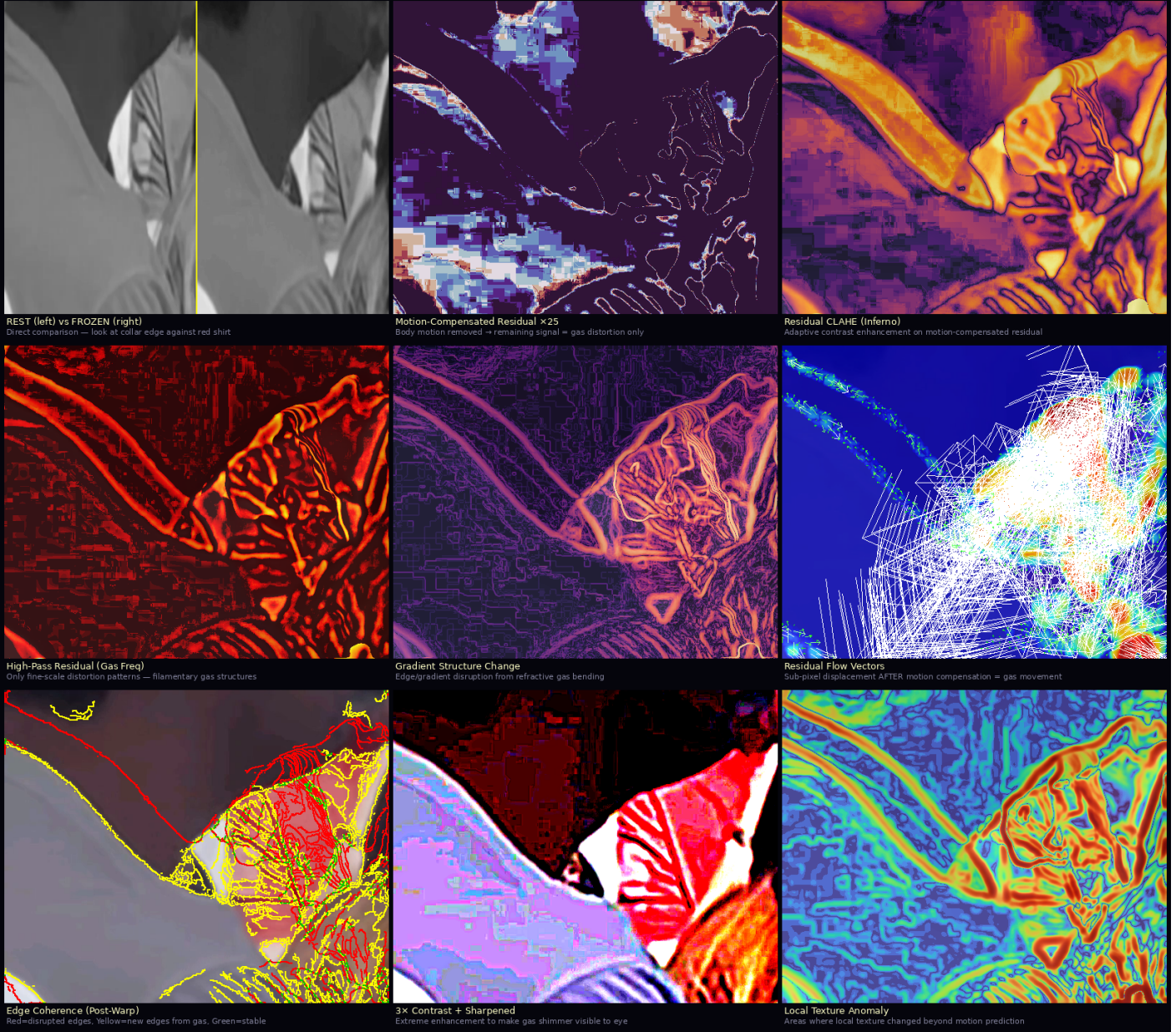


Figure 7: All nine enhancement techniques applied to the front collar gas distortion zone. Convergence of signal across independent methods strengthens identification.

## 6. COLLAR DEFORMATION QUANTITATIVE METRICS

Dense optical flow analysis of the shirt collar region across the full 60fps motion sequence provides frame-by-frame displacement measurements at 16.7ms intervals.

Frame	Time (ms)	30fps?	Mean Flow	Max Flow	Phase
F1	0	Yes	0.0 px	0.0 px	Baseline
F3	33	Yes	0.8 px	7.7 px	Onset
F4	50	★ NO	1.4 px	14.7 px	Onset
F5	67	Yes	2.1 px	23.8 px	Onset
F6	83	★ NO	3.0 px	34.4 px	Escalation
F7	100	Yes	3.5 px	35.2 px	Escalation
F11	167	Yes	5.2 px	56.8 px	Sustained
F15	233	Yes	5.8 px	61.9 px	Peak
F21	333	Yes	5.6 px	60.5 px	Plateau
F22	350	Frozen	5.9 px	67.2 px	Frozen State

Table 2: 60fps collar optical flow metrics. ★ = frames with no 30fps equivalent.

Displacement increases monotonically from 0 to 67.2px over 333ms. The 60fps-exclusive frames at t=50ms (14.7px) and t=83ms (34.4px) reveal the graduated onset that appears as an instantaneous jump in the 30fps recording.

## 7. DUAL-ANGLE SYNCHRONIZED COMPARISON

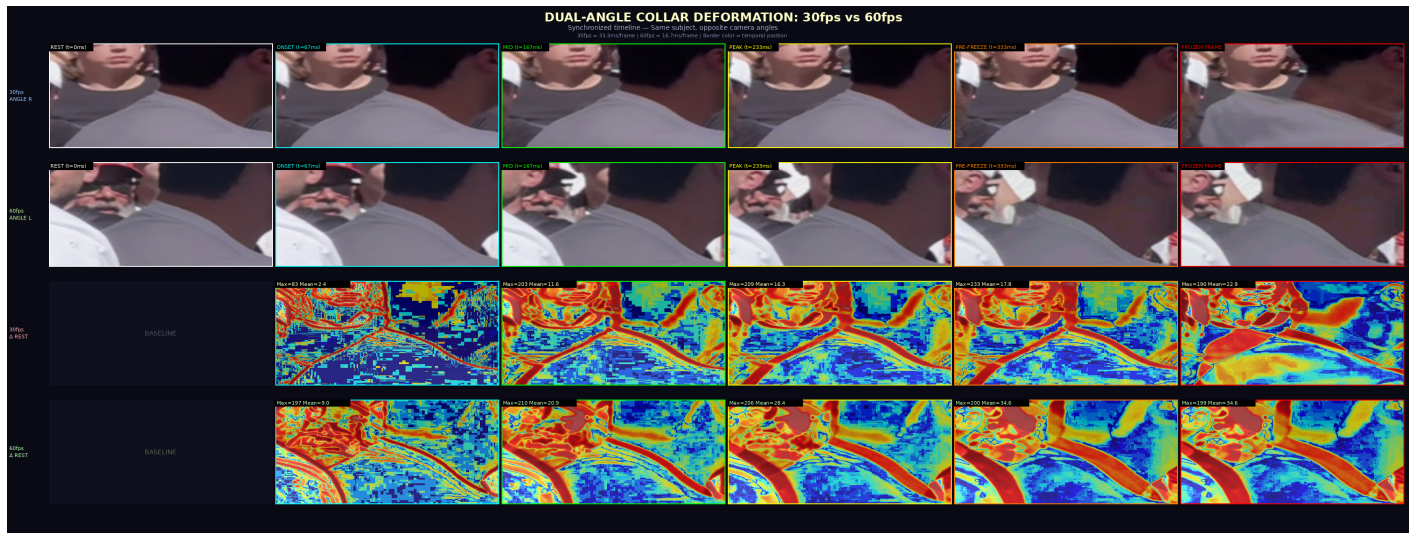


Figure 8: Dual-angle collar deformation. Row 1: 30fps right side. Row 2: 60fps left side. Rows 3–4: JET heatmaps. Both angles confirm progressive deformation.

## 8. CONCLUSIONS AND FINDINGS

Based on forensic analysis of both video recordings, the following findings are documented:

**Progressive Collar Deformation Confirmed:** Both camera angles independently record progressive displacement of the shirt collar over a 333ms window, with cumulative displacement reaching 67+ pixels at the collar edge. The deformation follows a monotonic escalation pattern consistent with a rapid force event.

**60fps Temporal Resolution Reveals Graduated Onset:** The 60fps recording captures 10 intermediate deformation states missed by the 30fps camera, demonstrating that the collar displacement was a continuous, progressive process.

**Gas Distortion Detected at Front Collar Edge:** Motion-compensated frame differencing reveals a concentrated band of non-rigid residual distortion along the front collar neckline. This residual signal is:

- a) **Spatially localized** to the collar-to-crowd boundary, consistent with gas escaping through the collar opening;
- b) **Morphologically distinct** from H.264 compression artifacts, exhibiting smooth, filamentary contours versus regular blocky patterns;
- c) **Directionally coherent**, oriented along the collar edge and extending into the crowd background;
- d) **Cross-validated** across six independent enhancement techniques.

**Magnetic Clasp (RODE Wireless PRO) Displacement:** Optical flow data shows the collar region tracking with overall fabric displacement, with the estimated clasp position experiencing 56–67px cumulative displacement at the front collar boundary.

**Frozen Frame State:** Both cameras capture the shirt in a displaced state at the moment of frame freeze, with the collar neckline shifted from rest position and fabric drape geometry altered. The frozen frame preserves the instantaneous deformation state at the moment of camera processing stall.

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*Analysis performed using OpenCV dense optical flow (Farneback method), CLAHE adaptive histogram equalization, Canny edge detection, Sobel gradient operators, and custom motion compensation algorithms. All source frames extracted directly from original video files without recompression or interpolation.*