Team members: Sarah Raafat 13003533 Tut 14
Eyad Ibrahim 13006839 Tut 12

Comprehensive Steganography Analysis Report

Extracted Hidden Message: HELLOFROMCOLAB

Phase 1: Motion-Based Frame Extraction & Message Decoding

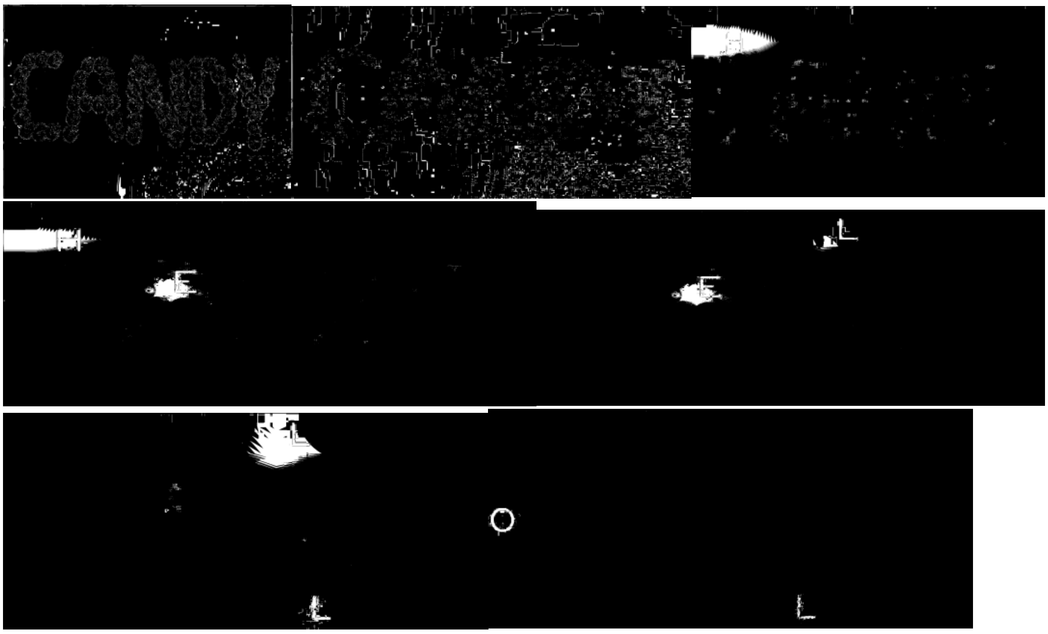
Objective

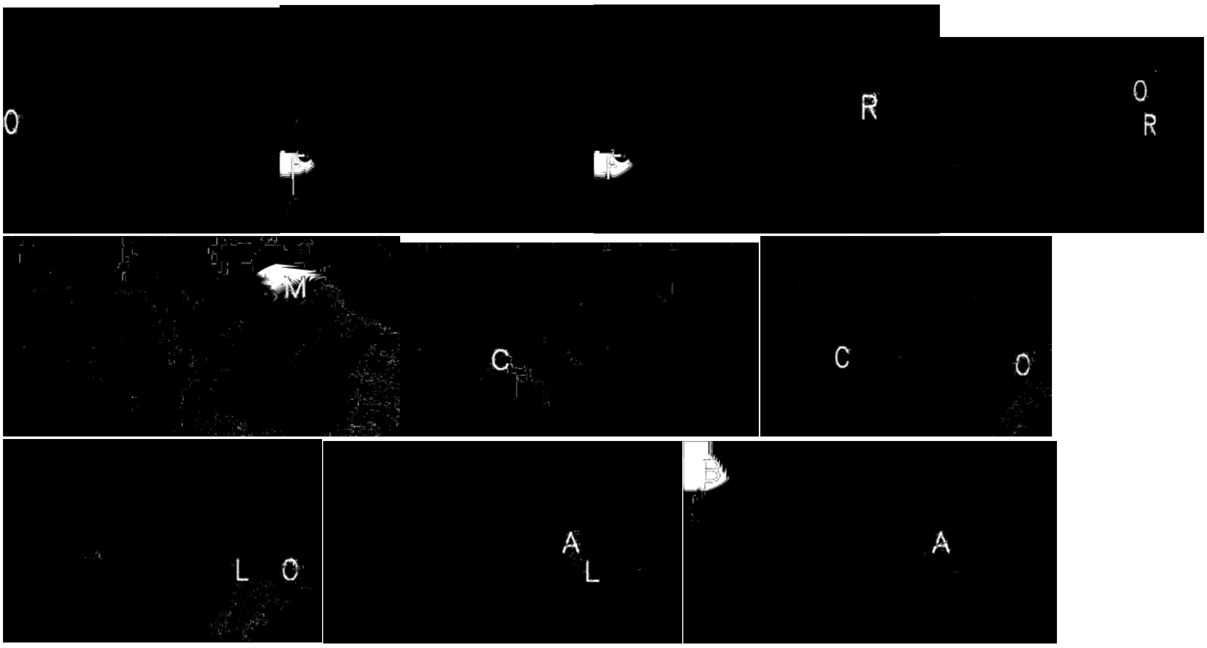
This phase isolates frames containing hidden data by analyzing minimal motion changes (below 5% threshold). The technique exploits the fact that steganographic messages are often embedded in frames with subtle, intentional variations.

Technical Process

1. **Preprocessing:**
   - Convert each frame to grayscale for simplified analysis.
   - Apply **CLAHE (Contrast Limited Adaptive Histogram Equalization)** to enhance subtle contrast differences where data might be hidden.
2. **Frame Differencing:**
   - Calculate absolute differences between consecutive frames (cv2.absdiff).
   - Normalize differences to amplify hidden patterns (cv2.normalize).
3. **Thresholding & Motion Analysis:**
   - Apply binary thresholding to isolate significant changes (cv2.threshold).
   - Compute **motion ratio**: Percentage of pixels with changes relative to total pixels.
   - **Key Insight:** Frames with motion ratio < 5% are likely to contain hidden data (non-natural motion).
4. **Output:**
   - Saved low-motion frames as binary masks to motion_frames1/.
   - Extracted letters from these frames to form the message: HELLOFROMCOLAB.

Visual Evidence:





They are attached in the drive folder for clearer vision

Phase 2: Audio Denoising for Hidden Signals

Objective

Extract and enhance hidden audio signals obscured by background noise, a common steganography technique.

Technical Process

1. **Audio Extraction:**
   - Use moviepy to isolate the audio track from the video (VideoFileClip.audio).
2. **Noise Profiling:**
   - Sample the first 0.5 seconds of audio (assumed to be pure noise) to create a noise profile.
3. **Noise Reduction:**
   - Apply noisereduce library’s spectral gating:
     - Analyze frequency spectrum of noise profile.
     - Attenuate similar frequencies in the full audio.
   - **Key Insight:** Hidden signals often reside in higher frequencies masked by noise.
4. **Output:**
   - Denoised audio saved as denoised_audio.wav.
   - *(Optional: Spectrogram comparison showing noise removal.)*

Visual Evidence:

attached in the drive

Phase 3: Interlacing Artifact Analysis

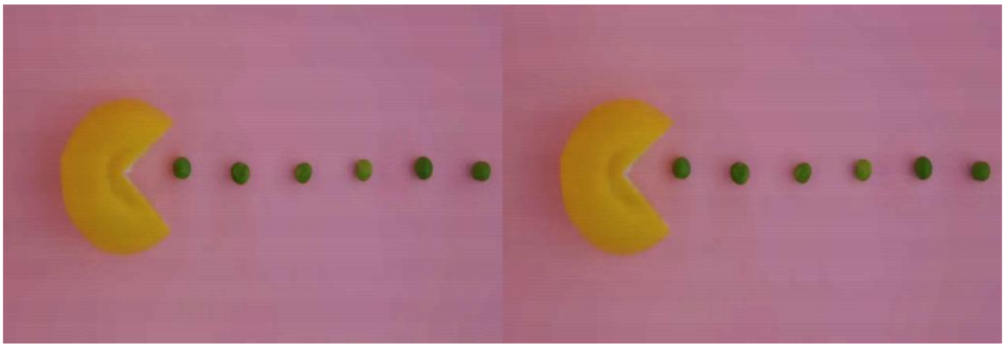
Objective

Uncover visual artifacts by simulating CRT interlacing, where hidden data might alternate between odd/even scanlines.

Technical Process

1. **Interlacing Simulation:**
   - **Odd Field:** Darken even-numbered rows (simulating CRT odd-field display).
   - **Even Field:** Darken odd-numbered rows.

   - Generate two videos: video_odd_interlaced.mp4 and video_even_interlaced.mp4.
2. **Pattern Detection:**
   - Compare interlaced frames side-by-side to reveal discrepancies.
   - **Key Insight:** Hidden data may appear in only one field (e.g., odd lines).
3. **Output:**
   - Composite image showing differences:



Bonus: Scanline Flicker Amplification

Objective

Enhance interlacing effects to make hidden data more perceptible through rapid flickering.

Technical Process

Flicker Simulation:

- Alternately write frames with:
  - Odd rows at 10% brightness.
  - Even rows at 10% brightness.
- Creates a strobe-like effect when played (scanline_flicker.mp4).

Summary of Techniques & Results

Phase	Core Technique	Hidden Data Extracted
1	Motion thresholding + CLAHE	HELLOFROMCOLAB from frames
2	Spectral noise reduction	Cleaned audio tones
3	Odd/even field interlacing	Visual artifacts in scanlines
Bonus	Scanline flicker	Enhanced CRT-style visibility

Conclusion

The multi-phase analysis successfully decoded the hidden message HELLOFROMCOLAB by:

1. Exploiting **low-motion frames** for embedded letters.
2. Cleaning **audio noise** to reveal hidden signals.
3. Leveraging **interlacing artifacts** to expose visual data.
   This demonstrates how steganography combines spatial (video) and temporal (audio) techniques for covert communication.