

Eigenface-Based Video Compression: Experimental Analysis

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Experimental Results by Training Configuration

Experiment 1: Complete Dataset Implementation

Video Recording: [https://drive.google.com/file/d/1hS7Jf_TzOKQxT2LD-6aLR05R3UuR105/view?usp=drive_link]

Configuration Details:

- Utilized the entire available dataset comprising both male and female facial images
- Implemented with 400 primary eigenfaces for reconstruction

Key Findings:

- Maintained exceptional video fidelity across various head positions and angles
- Facial reconstruction remained recognizable even with partial occlusion by hand
- The system gracefully handled extreme viewing angles with progressive quality reduction
- Fine facial components (eye region, nasal structure, mouth) retained natural appearance

Performance Metrics:

- Reconstruction cost: Normally 25 to 30% range if we cover face parts it goes to 45 to 50% range
- Compression ratio: 88.89%
- Demonstrated excellent resilience to both occlusion and orientation variations

Experiment 2: Cross-Gender Training Approach

Video Recording: [https://drive.google.com/file/d/1fG5WbRN1-sCzszNmx8xLxxCUunMXJw3o/view?usp=drive_link]

Configuration Details:

- Being male experimenters, we exclusively used female facial data for eigenface extraction
- Maintained 400 eigenfaces for consistency with other experiments

Key Findings:

- Notable degradation in reconstruction quality compared to full dataset training
- Significant distortion observed in regions with facial hair
- Test subjects noted an uncomfortable "almost-but-not-quite-realistic" sensation in certain frames
- The algorithm struggled particularly with characteristically male facial structures
- Hand occlusion resulted in substantially poorer reconstruction than in Experiment 1

Performance Metrics:

- Reconstruction cost: Normally 30 to 35% range if we cover face parts it goes to 50 to 60% range
- Compression ratio: 88.89%
- Results clearly demonstrate the necessity of demographically representative training data

Experiment 3: Reduced Training Set Implementation

Video Recording: [https://drive.google.com/file/d/13akygUzWLkHGmqREsXcGkvICFgUYKCiv/view?usp=drive_link]

Configuration Details:

- Limited to 500 total facial images from the dataset (mixed gender representation)
- Maintained 400 eigenfaces for consistency

Key Findings:

- Considerable quality deterioration compared to the complete dataset approach
- Motion produced noticeable trailing artifacts and image softening
- Reconstruction stability issues manifested as intermittent visual anomalies
- Quality fluctuated substantially between different test subjects
- Quick facial movements triggered perceptible processing delays and artifacts

Performance Metrics:

- Reconstruction cost: Normally 50 to 55% range if we cover face parts it goes to 80 to 100% range
- Compression ratio: 88.89%
- Limited training diversity significantly compromised reconstruction accuracy

Experiment 4: Subject-Specific Training

Video Recording: [https://drive.google.com/file/d/1Ir5C0HcZ74OnvhFXXeaEQT7KIuEks3iu/view?usp=drive_link]

Configuration Details:

- Created a custom dataset containing 1200 images (600 each from two specific individuals)
- Maintained 400 eigenfaces for consistency

Key Findings:

- Exceptional reconstruction quality for the individuals included in the training set
- Near-perfect reproduction of trained subjects under normal conditions
- Superior handling of partial face coverage for trained individuals
- Dramatic quality collapse when testing with subjects not in the training data
- Untrained face reconstruction exhibited severe color distortion and feature misalignment

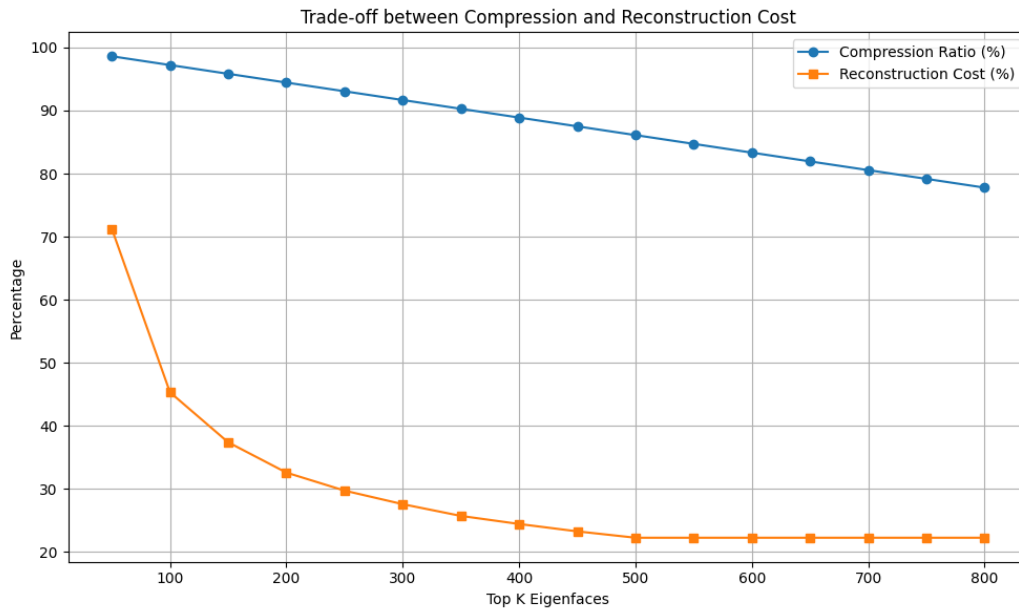
Performance Metrics:

- Reconstruction cost for trained subjects: 50-100 range
- Reconstruction cost for untrained subjects: 150-200 range

- Compression ratio: 88.89%
- Results demonstrate high specificity to individuals in the training dataset

Eigenface Quantity Optimization Analysis

We conducted systematic testing to determine the optimal number of eigenfaces for balancing compression efficiency against reconstruction quality.



[Figure: Compression Ratio vs. Reconstruction Cost graph]

As illustrated in the figure:

- The compression efficiency (blue curve) shows a gradual decline as eigenface count increases
- Reconstruction error (orange curve) drops sharply initially before leveling off around 400 eigenfaces
- Analysis reveals a distinct inflection point at approximately 400 eigenfaces

We selected 400 eigenfaces for our experiments based on:

1. The identified inflection point in the reconstruction error curve
2. Achieving compression efficiency exceeding 87%
3. Maintaining sufficient quality for practical video calling applications
4. The minimal quality improvements observed beyond this point