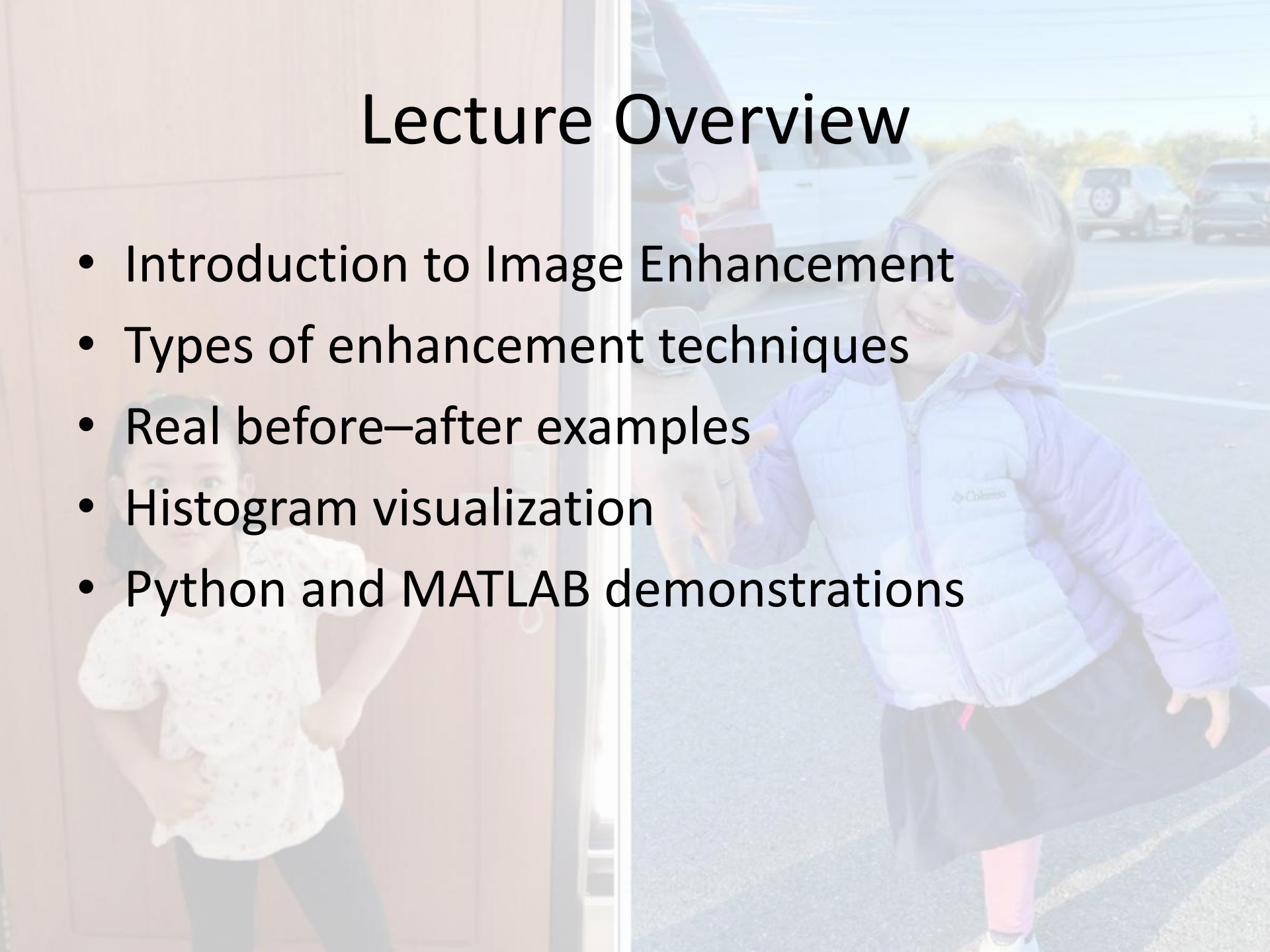
Image Enhancement Techniques

Real Examples, Histogram Visualization, and MATLAB Demonstrations

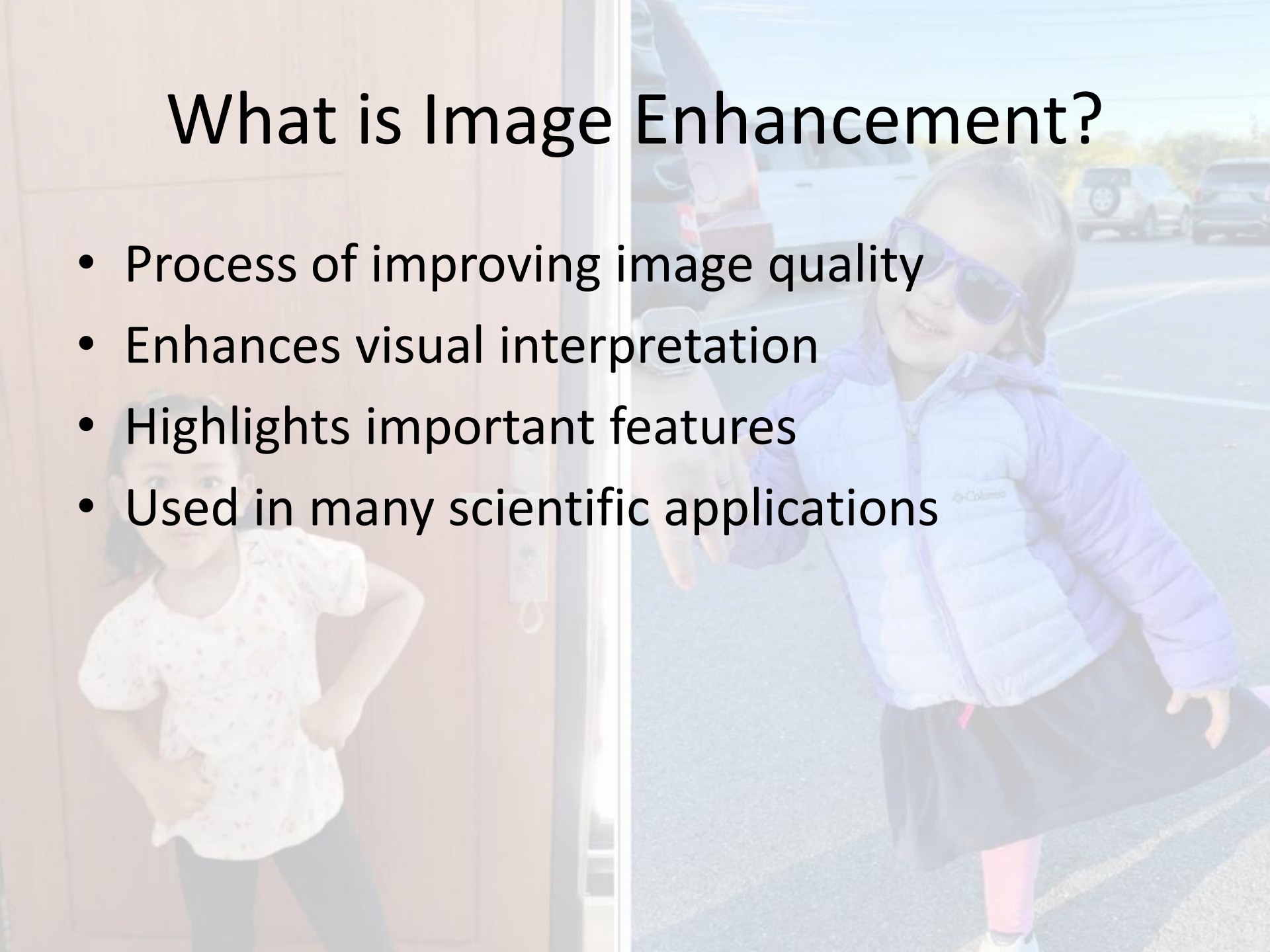
Lecture Overview

- Introduction to Image Enhancement
- Types of enhancement techniques
- Real before–after examples
- Histogram visualization
- Python and MATLAB demonstrations



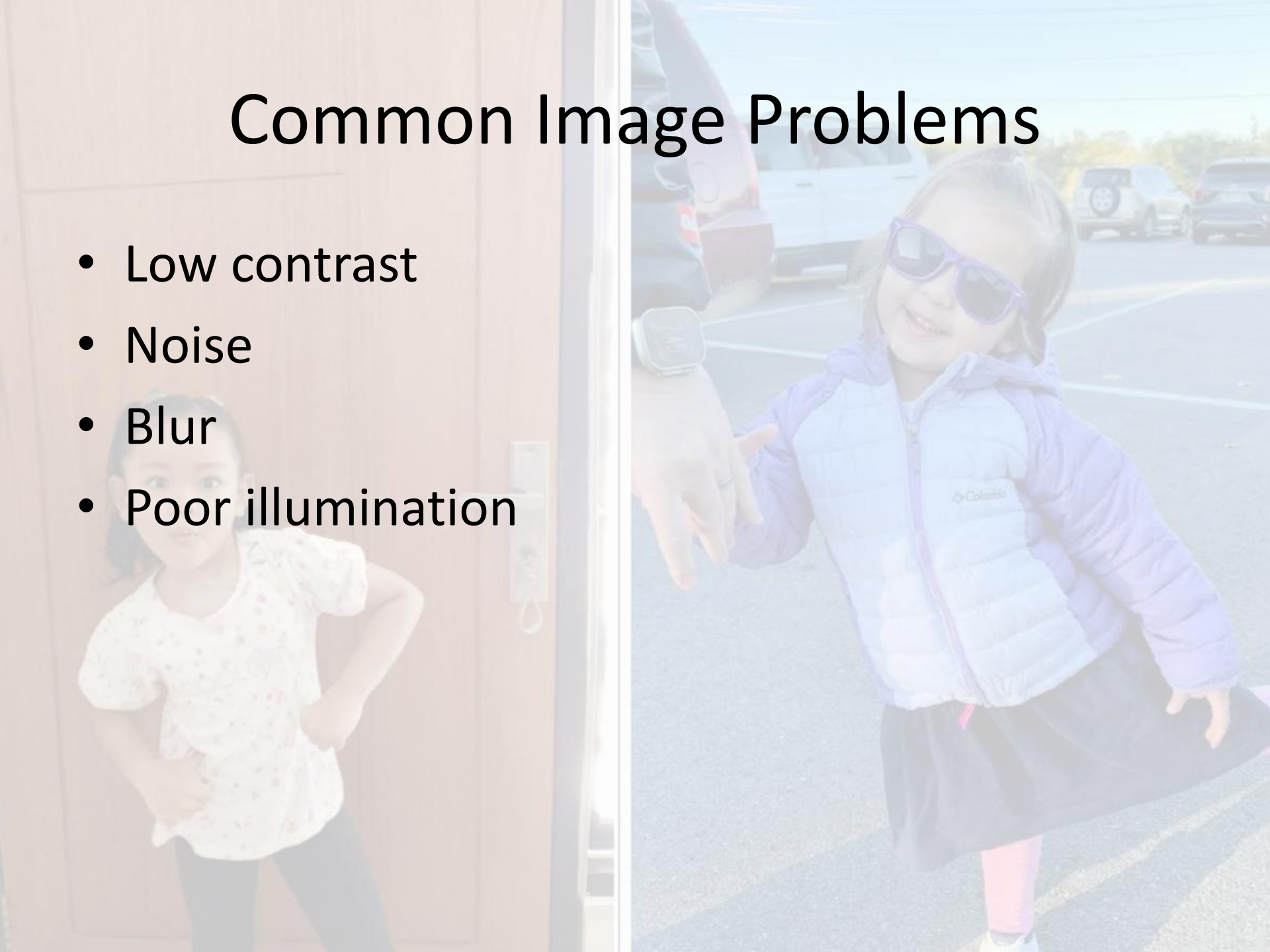
What is Image Enhancement?

- Process of improving image quality
- Enhances visual interpretation
- Highlights important features
- Used in many scientific applications



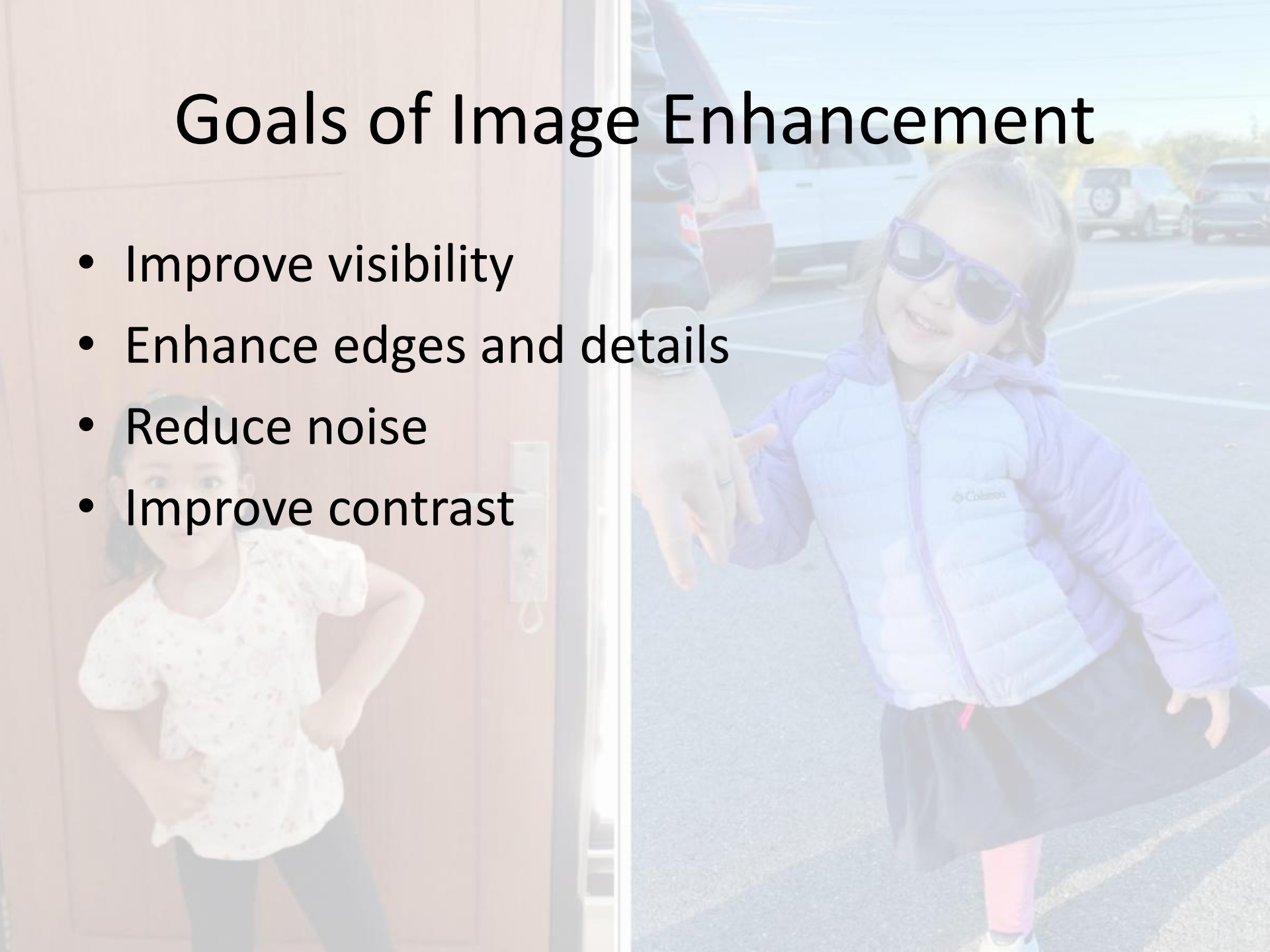
Common Image Problems

- Low contrast
- Noise
- Blur
- Poor illumination



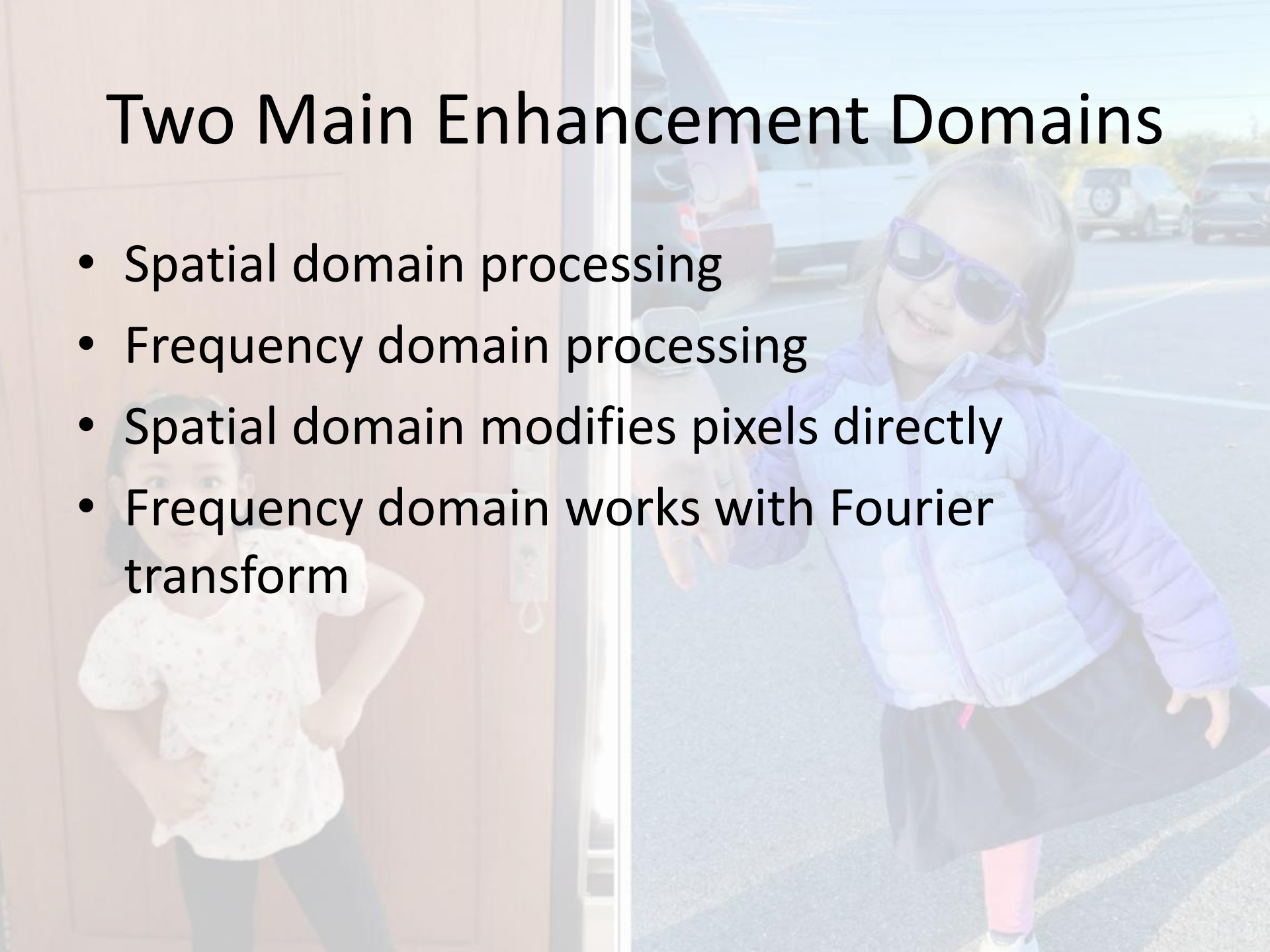
Goals of Image Enhancement

- Improve visibility
- Enhance edges and details
- Reduce noise
- Improve contrast



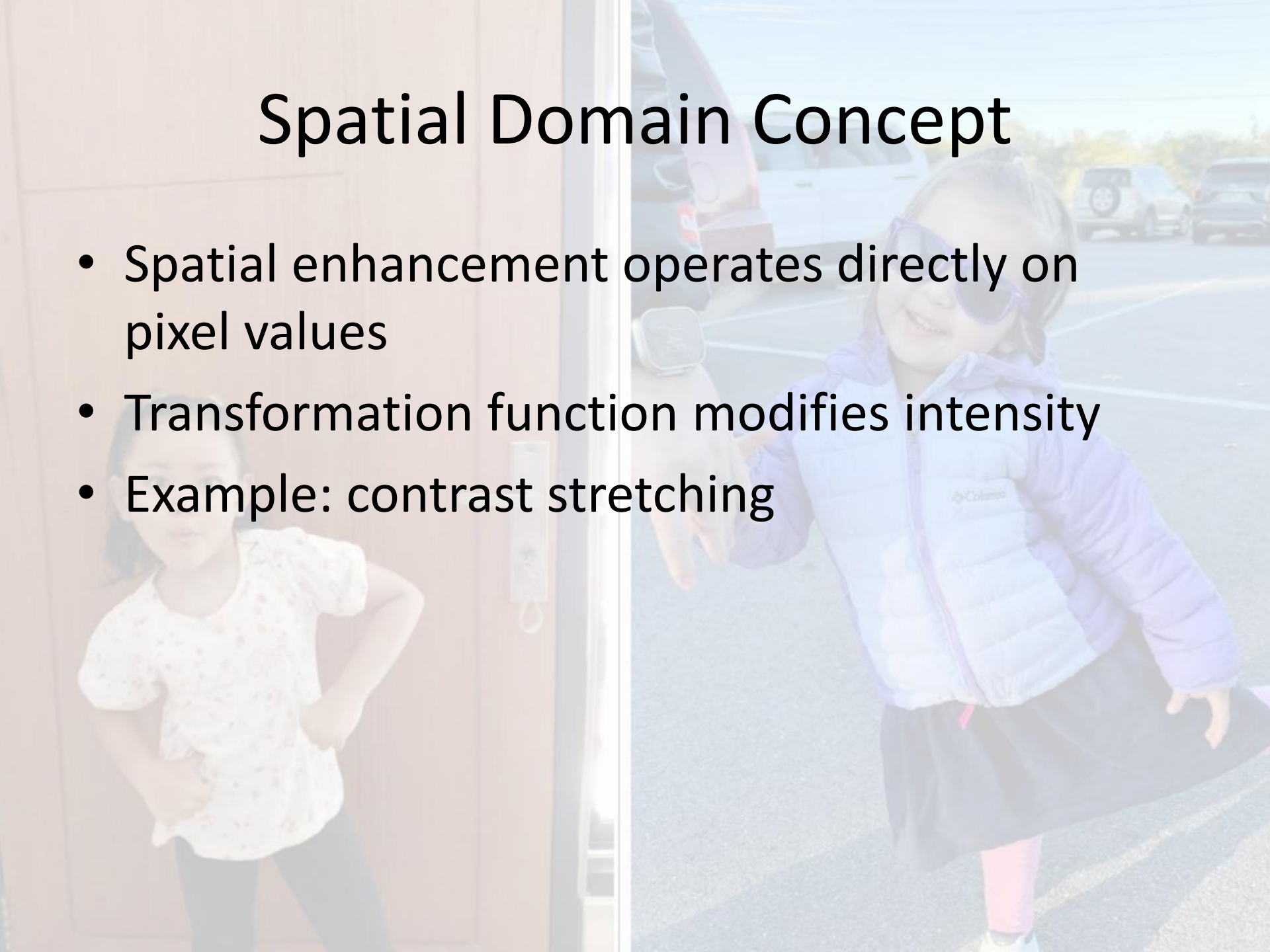
Two Main Enhancement Domains

- Spatial domain processing
- Frequency domain processing
- Spatial domain modifies pixels directly
- Frequency domain works with Fourier transform



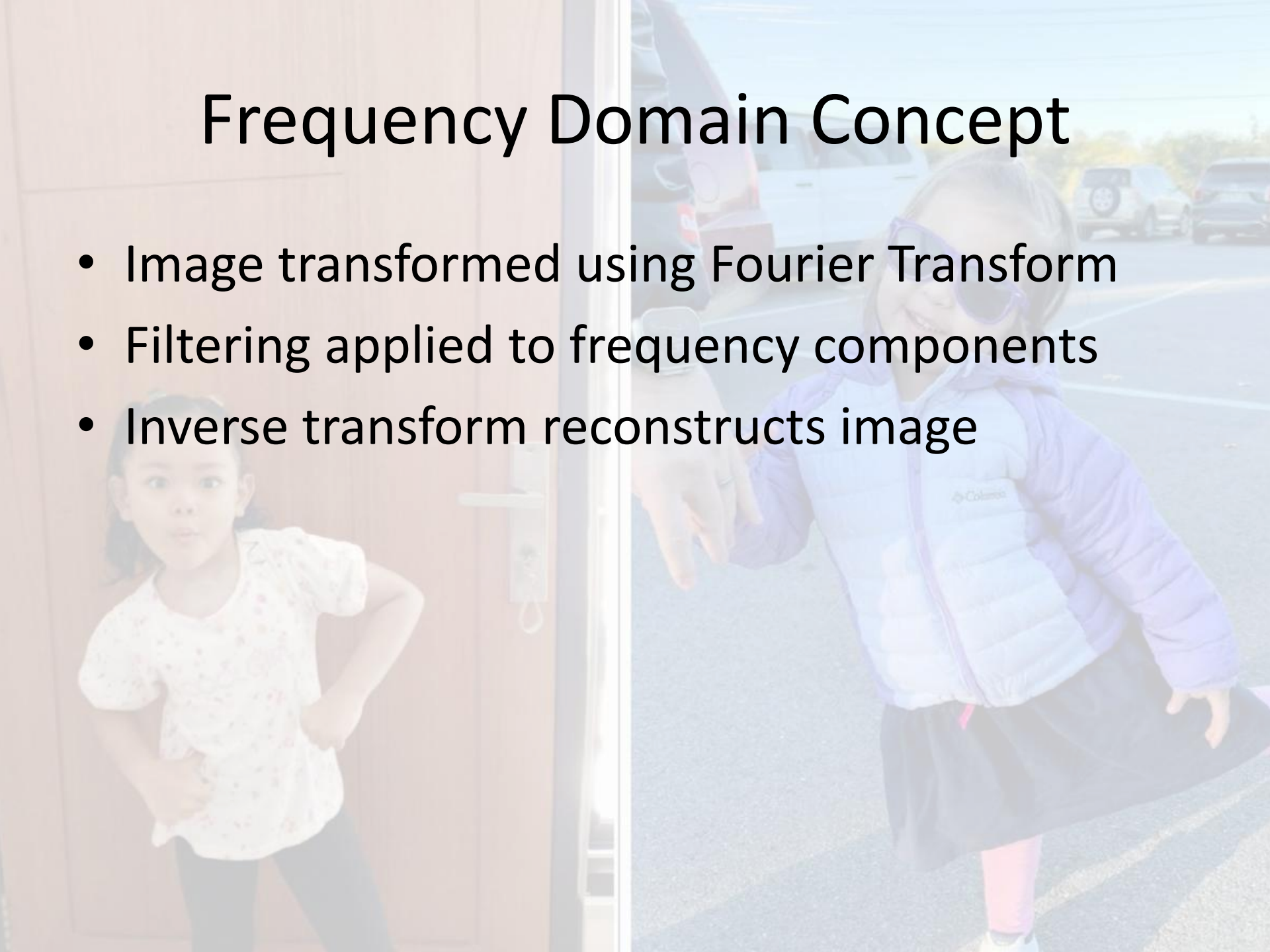
Spatial Domain Concept

- Spatial enhancement operates directly on pixel values
- Transformation function modifies intensity
- Example: contrast stretching



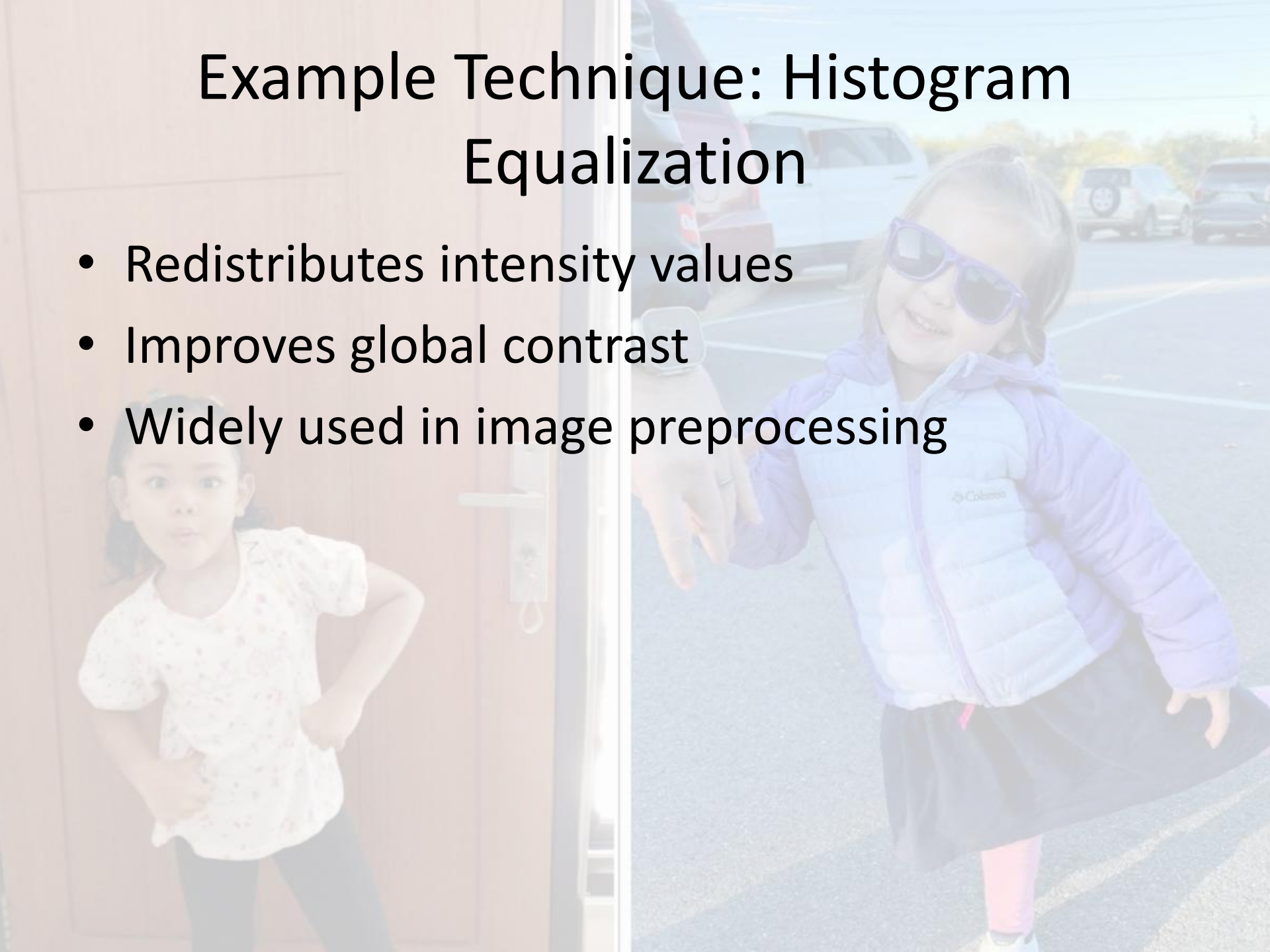
Frequency Domain Concept

- Image transformed using Fourier Transform
- Filtering applied to frequency components
- Inverse transform reconstructs image

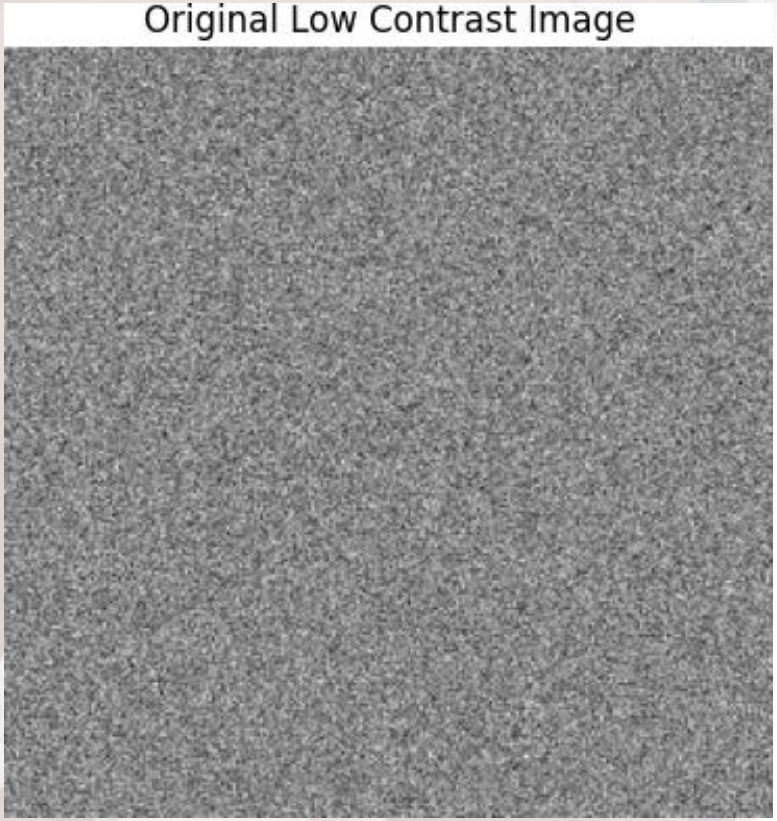


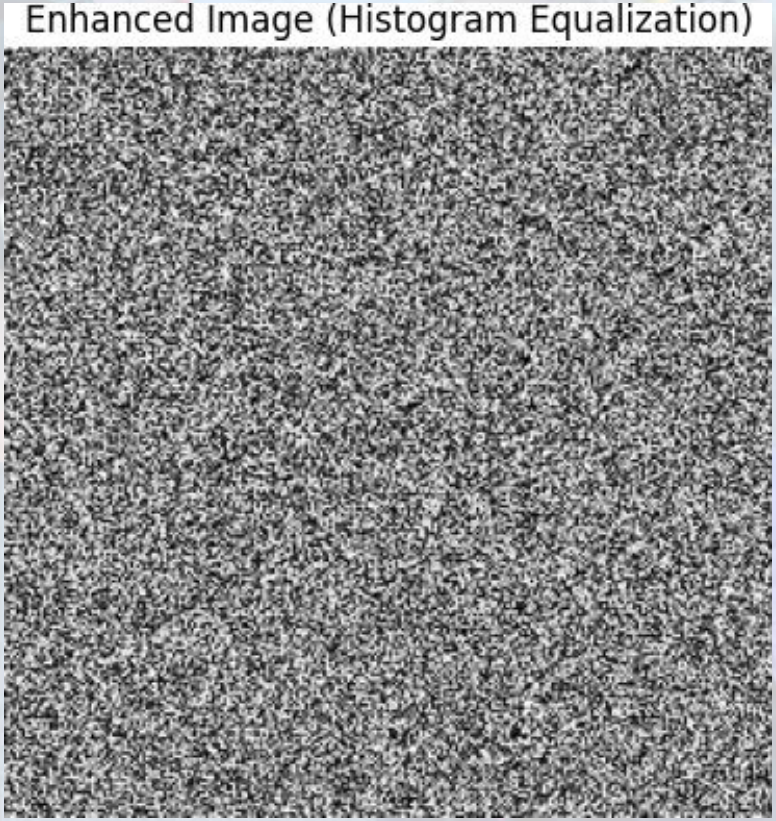
Example Technique: Histogram Equalization

- Redistributes intensity values
- Improves global contrast
- Widely used in image preprocessing

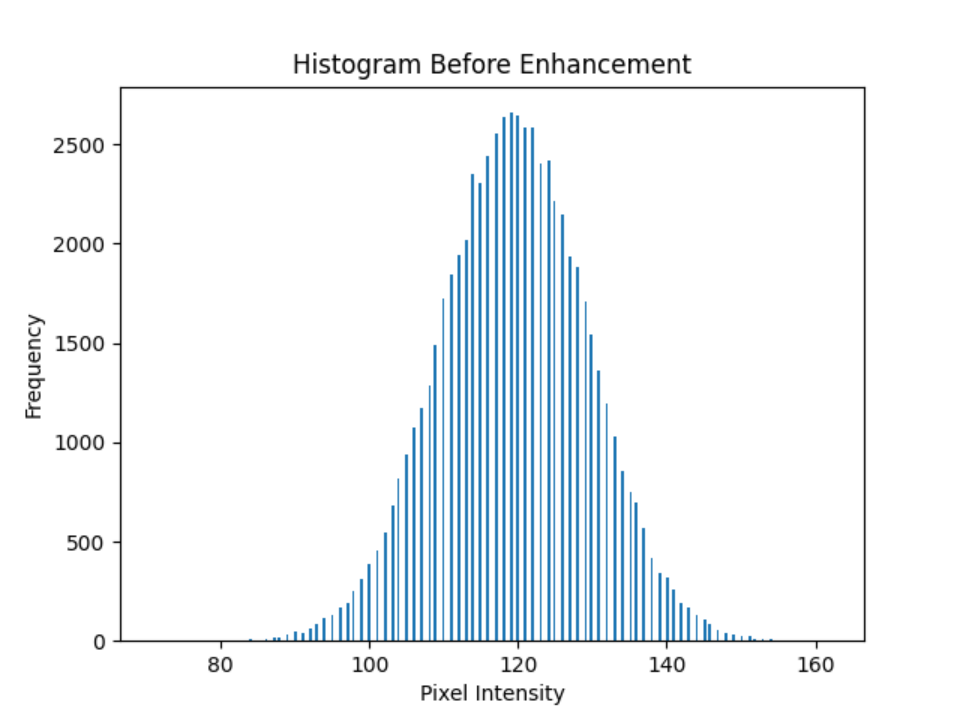


Real Example: Before vs After Enhancement

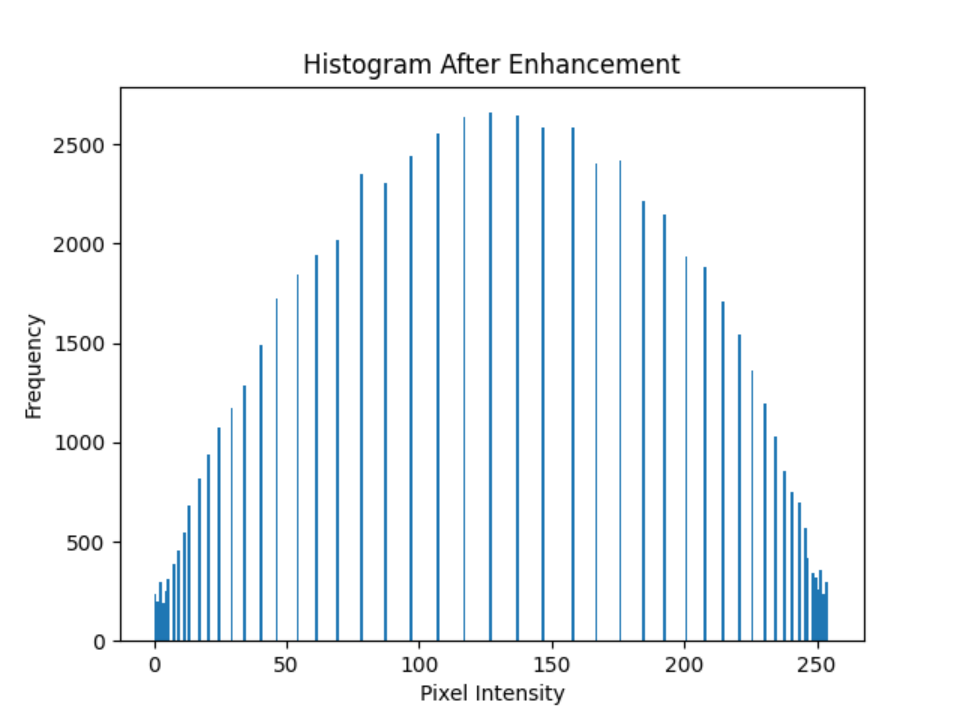




Histogram Before Enhancement



Histogram After Enhancement



Observation from Histogram

- Before enhancement: narrow intensity range
- After enhancement: wider distribution
- Improved image contrast

Image Smoothing Techniques

- Mean filter
- Median filter
- Gaussian filter

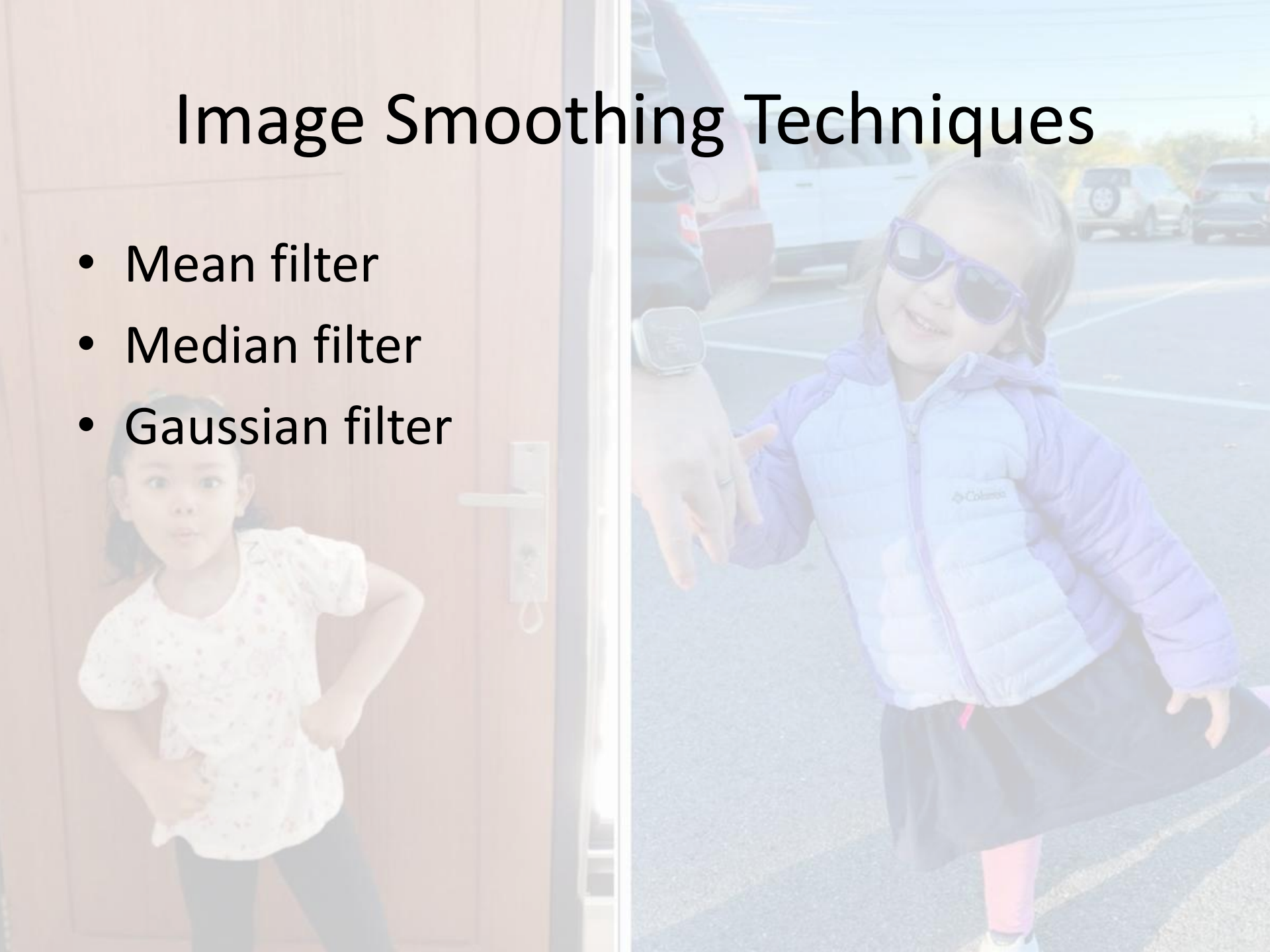
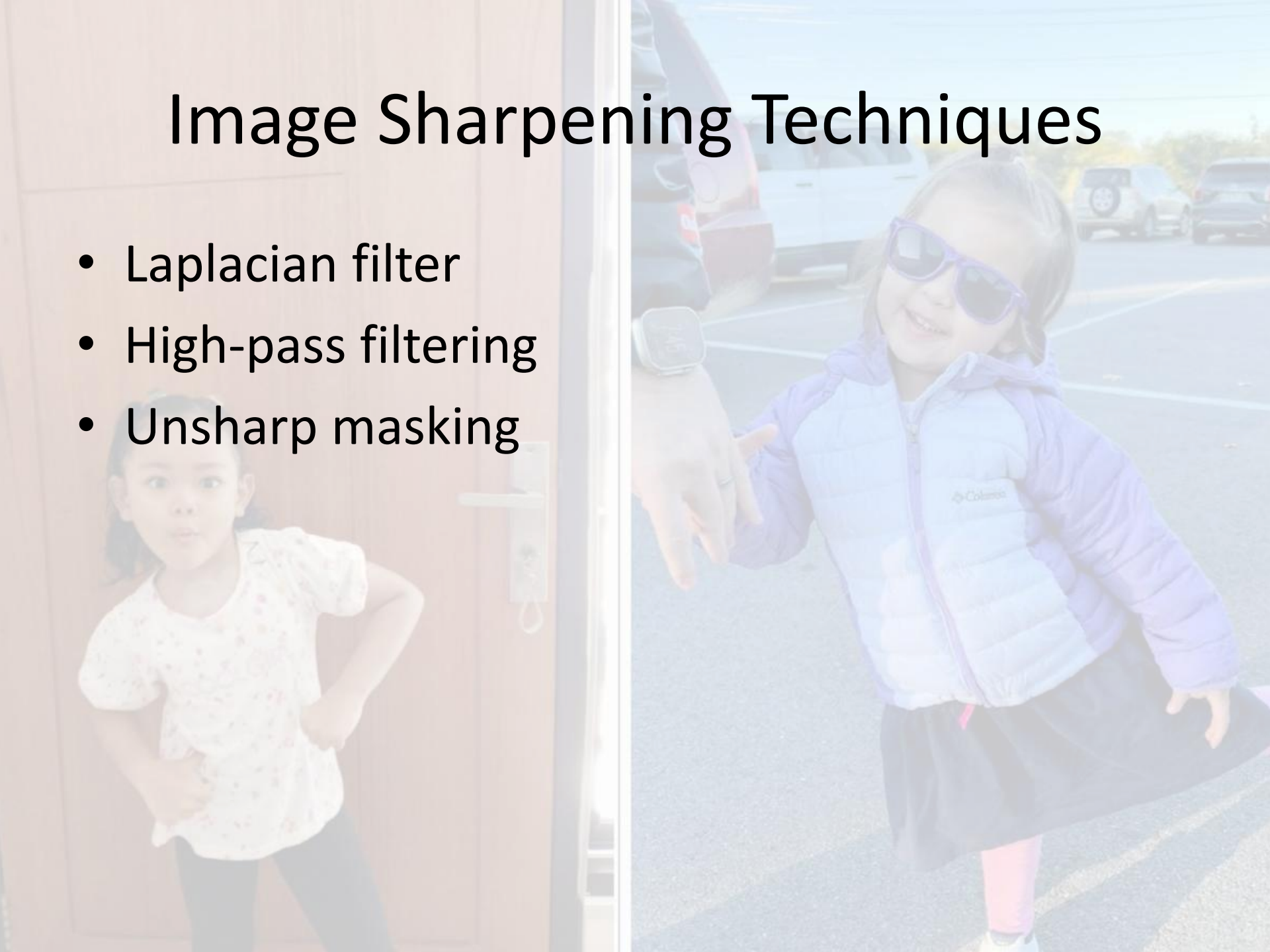


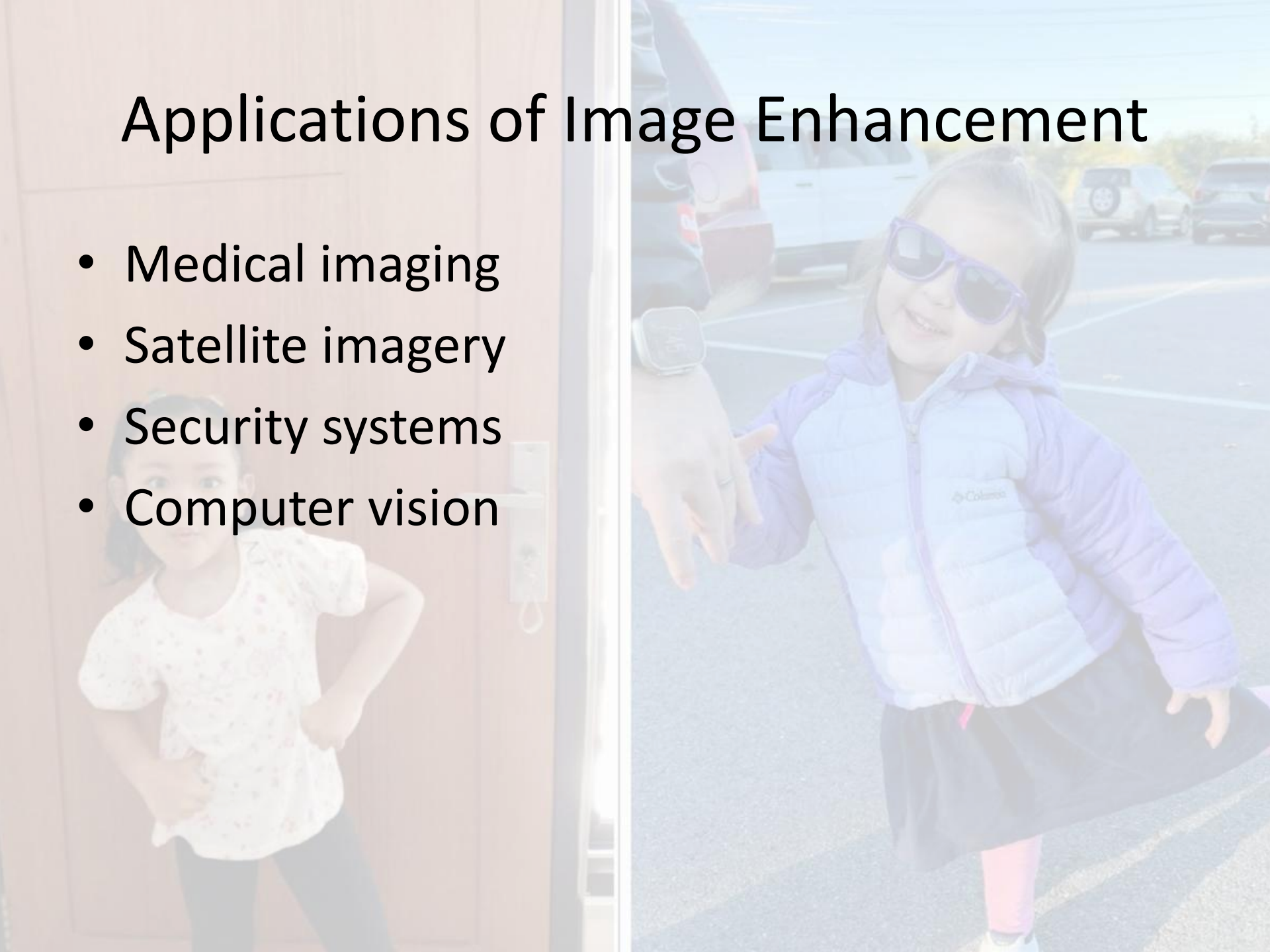
Image Sharpening Techniques

- Laplacian filter
- High-pass filtering
- Unsharp masking



Applications of Image Enhancement

- Medical imaging
- Satellite imagery
- Security systems
- Computer vision

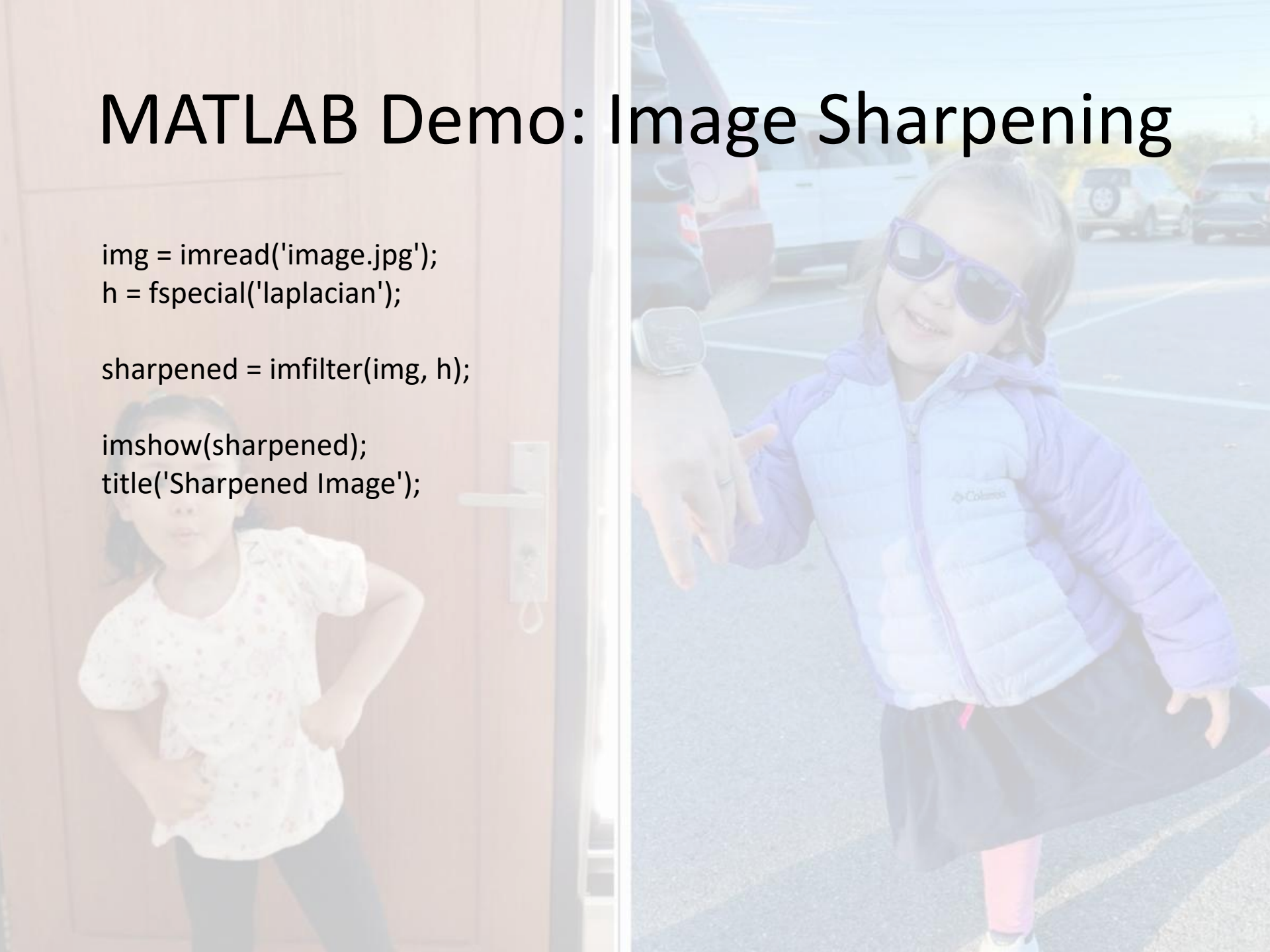


MATLAB Demo: Histogram Equalization

```
img = imread('image.jpg');
gray = rgb2gray(img);

enhanced = histeq(gray);

subplot(1,2,1);
imshow(gray);
title('Original Image');

subplot(1,2,2);
imshow(enhanced);
title('Enhanced Image');
```

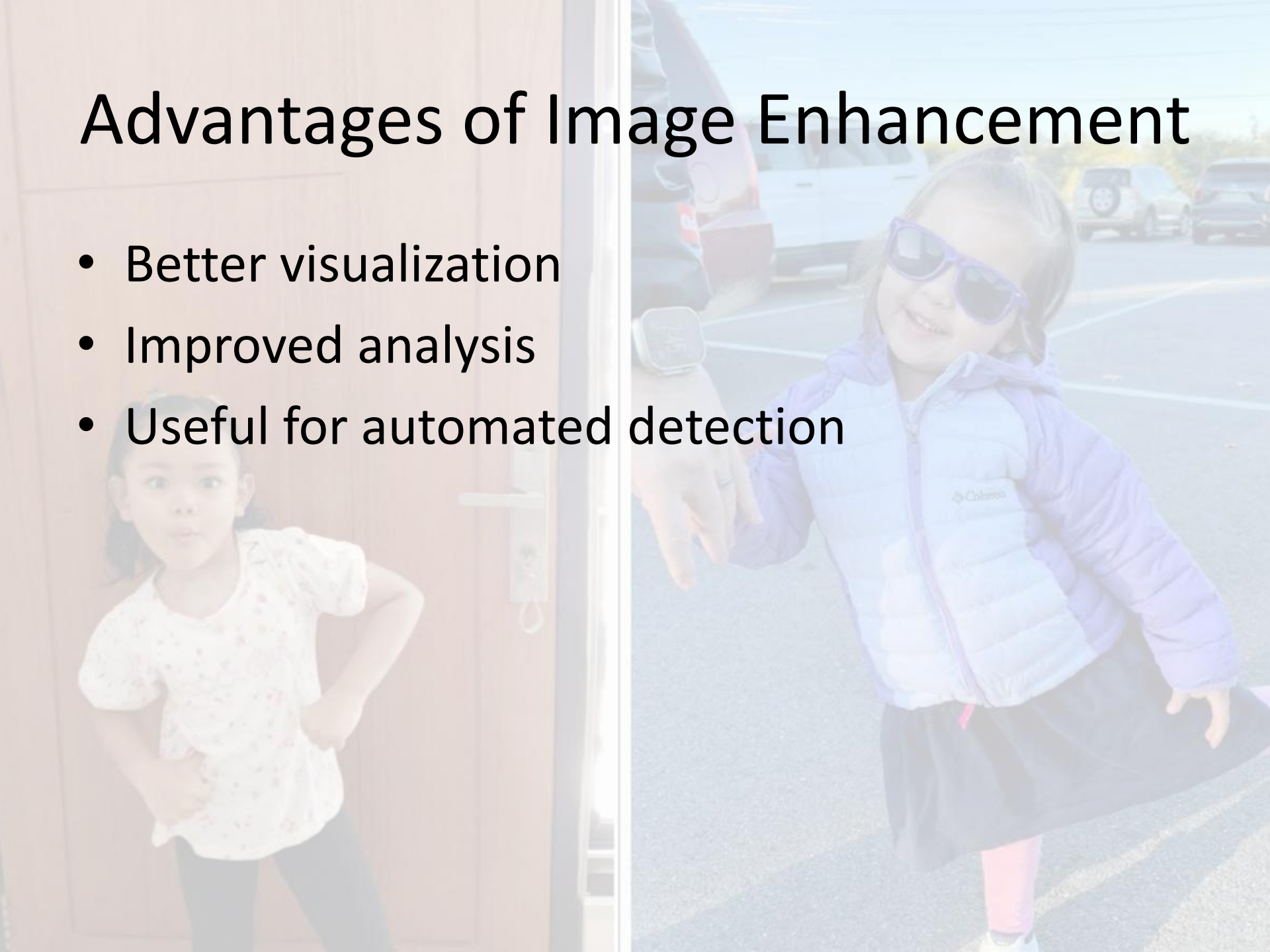
MATLAB Demo: Image Sharpening

```
img = imread('image.jpg');
h = fspecial('laplacian');

sharpened = imfilter(img, h);

imshow(sharpened);
title('Sharpened Image');
```



Advantages of Image Enhancement

- Better visualization
- Improved analysis
- Useful for automated detection



Limitations

- Over enhancement
- Noise amplification
- Possible loss of information

Future Research Trends

- Deep learning-based enhancement
- AI image restoration
- Real-time video enhancement

Summary

- Image enhancement improves image quality
- Multiple techniques exist
- Important in many fields

References

- Gonzalez & Woods – Digital Image Processing
- Linda Saporo i – Computer Vision