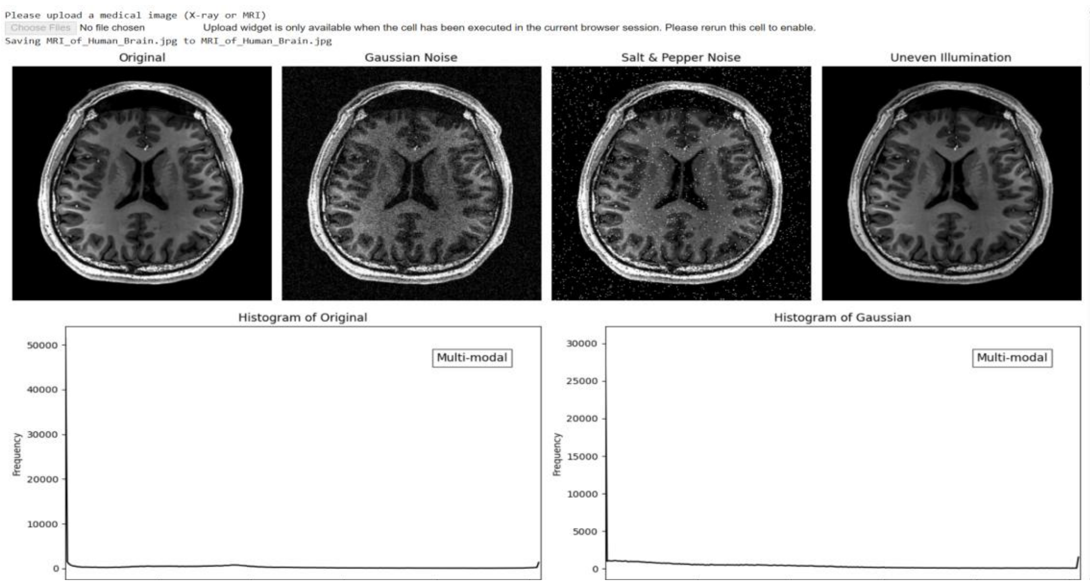
Smart Segmentation Analysis Report

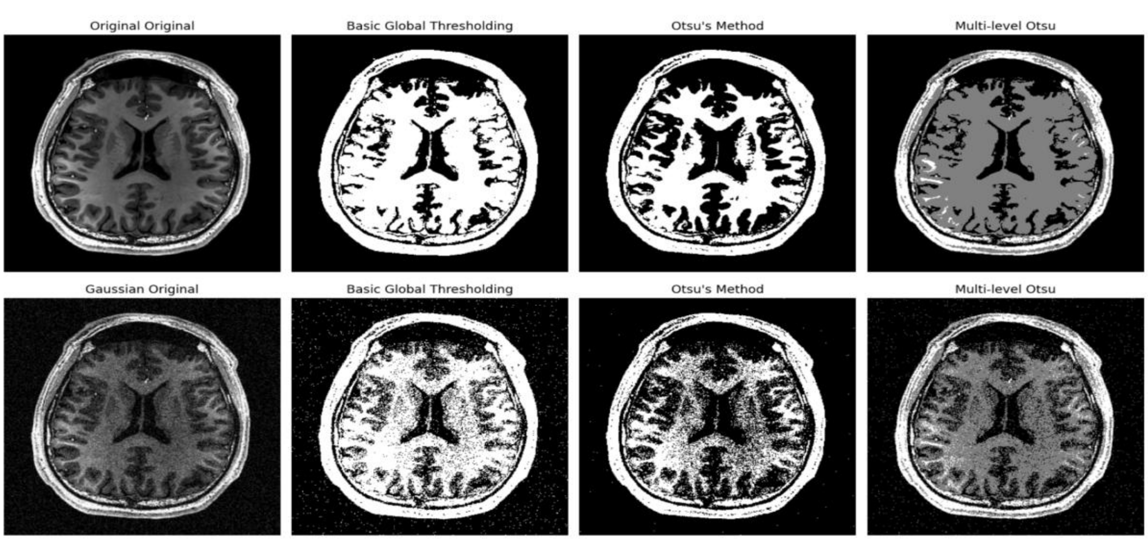
Noise and Illumination Effects Analysis

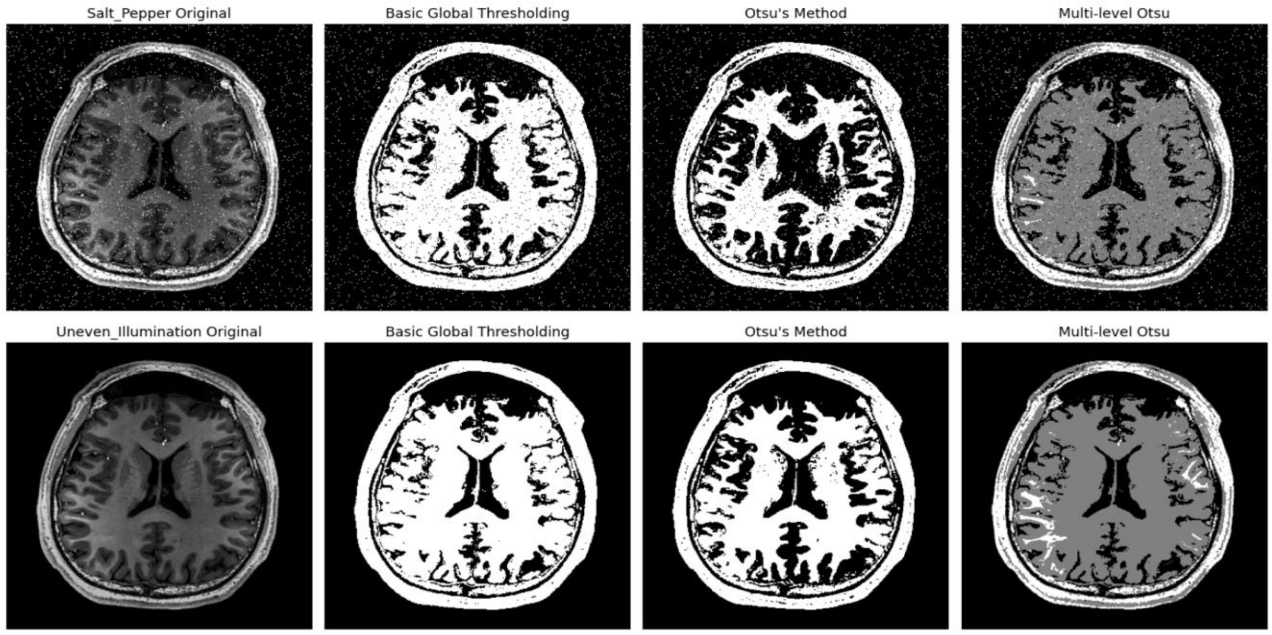
Based on the results shown in the images, The following effects when different types of noise and illumination changes are applied to medical brain MRI images:



Before and After Noise Comparison

Noise Type	Effect on Image	Effect on Segmentation
Gaussian Noise	Adds random intensity variations across the image	Degrades edge detection; creates false boundaries
Salt & Pepper Noise	Introduces random white and black pixels	Creates isolated segments; interrupts region continuity
Uneven Illumination	Darkens the periphery while maintaining center brightness	Creates brightness-based segmentation bias

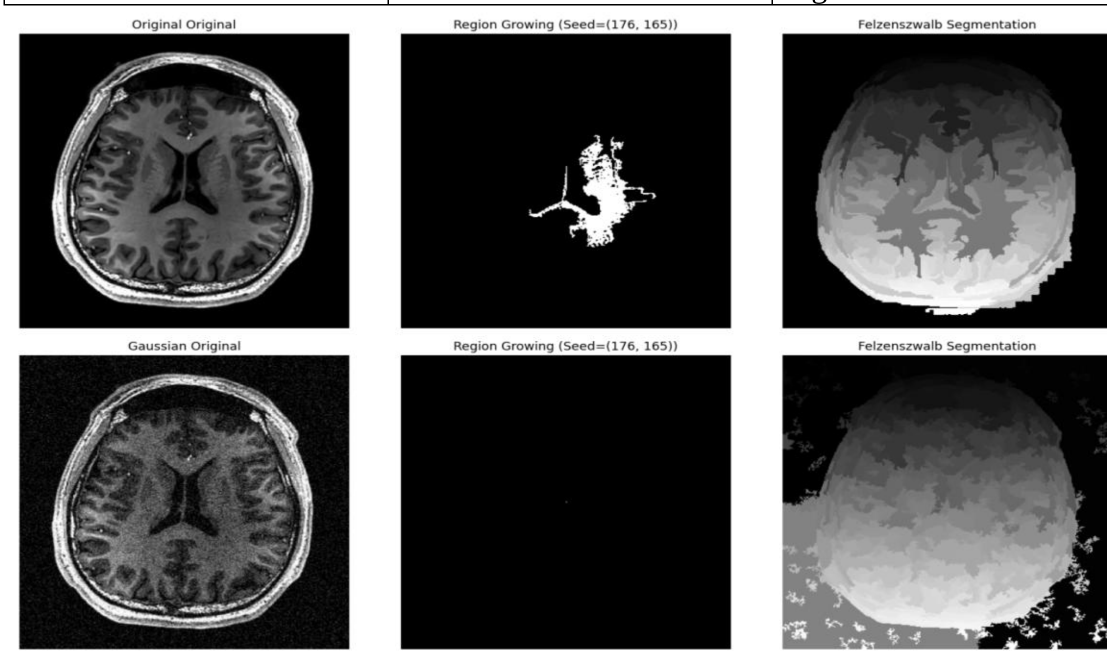




Thresholding vs. Region-Based Segmentation

Performance Comparison

Method	Strengths	Weaknesses
Basic Global Thresholding	Simple and fast	Highly sensitive to noise and illumination changes
Otsu's Method	Adapts threshold based on histogram	Performs poorly with non-bimodal distributions
Multi-level Otsu	Handles multiple intensity regions	Can oversegment with noise present
Region Growing	Preserves spatial continuity	Very sensitive to seed point selection
Felzenszwalb	Handles texture variations well	May produce irregular region boundaries



Method Performance Analysis

Which method handled noise or lighting changes better?

- Noise Handling:
  - Otsu's method performed reasonably well with Gaussian noise but struggled with Salt & Pepper noise
  - Region Growing was severely affected by all noise types, showing inconsistent region growth
  - Felzenszwalb showed better resilience to Salt & Pepper noise but still produced over-segmentation

- Lighting Changes:
  - Global thresholding completely failed with uneven illumination
  - Otsu's method showed moderate adaptation but still segmented based on brightness rather than anatomy
  - Felzenszwalb demonstrated the best performance with uneven illumination, preserving major anatomical structures

How did the histogram change?

- Original Image: The histogram shows a multi-modal distribution with distinct peaks corresponding to different tissue types
- Gaussian Noise: The histogram peaks became wider and less defined, reducing the separation between tissue classes
- Salt & Pepper Noise: Added small peaks at the extreme ends (0 and 255) without significantly changing the central distribution
- Uneven Illumination: Shifted the histogram toward darker values and compressed the dynamic range, making tissue distinction more difficult

Final Recommendations

1. For clean medical images:
   - Otsu's Method provides excellent results for initial segmentation
   - Region Growing with properly selected seed points can isolate specific anatomical structures

2. For noisy images:
   - Apply noise reduction techniques before segmentation
   - Felzenszwalb algorithm provides better noise resilience than thresholding methods
   - Consider combining methods: use Otsu for initial segmentation, followed by region-based refinement

3. For uneven illumination:
   - Apply illumination correction as preprocessing
   - Felzenszwalb shows the best adaptation to illumination changes
   - Avoid global thresholding entirely for images with uneven lighting

4. General strategy:
   - Preprocessing is critical: address noise and illumination issues before segmentation
   - The histogram shape should guide method selection:
     - Bi-modal histograms → Otsu's method
     - Complex multi-modal distributions → Multi-level Otsu or Felzenszwalb
   - For targeted segmentation of specific structures, Region Growing with manually selected seeds outperforms automatic methods

5. Hybrid approach recommendation:
   - For optimal results in challenging conditions, implement a pipeline that:
     1. Applies appropriate preprocessing based on image quality assessment
     2. Uses Otsu's method for initial segmentation
     3. Refines results with region-based methods in areas of interest
     4. Evaluates results against anatomical priors when available