

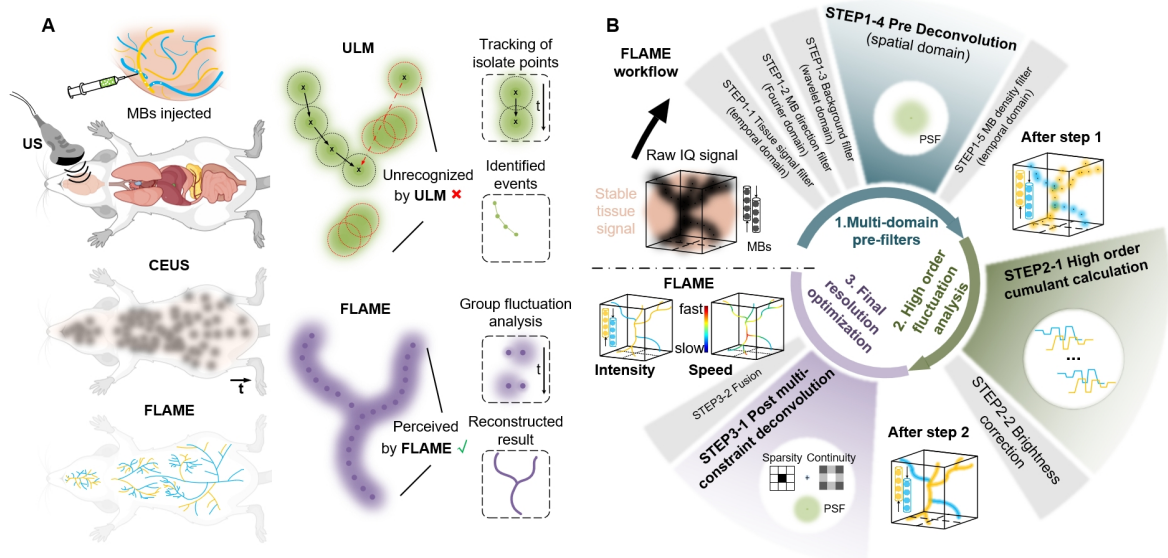
# FLAME<sup>m</sup>

## FLuctuation-based high-order super-resolution Acoustic MicroscopeE

### FLAME reconstruction with MATLAB

This repository is for our developed FLuctuation-based high-order super-resolution Acoustic MicroscopeE (FLAME), and it will be in continued development. It is distributed as accompanying software for publication: Weisong Zhao et al. High-throughput 3D super-resolution ultrasound imaging, Nature, submitted (2025). Please cite FLAME in your publications, if it helps your research.

## FLAME reconstruction



## Instruction

Load the target mat file using load and change the variable name to input. The FLAME reconstruction requires some parameters.

### Necessary Parameters

Important parameters that must be set according to actual needs.

`SVD_option` Enable SVD filtering. {default: 0}

`MB_option` Enable MB (multi-band) direction filtering. {default: 0}

`pixel` Pixel size of input data ( $\mu\text{m}$ ). {default: 60}

**fidelity** Sparsity reconstruction fidelity (controls data fidelity term weight). *{default: 200}*

**sparsity** Sparsity reconstruction strength (controls sparsity term weight). *{default: 10}*

**FWHM2** Full-width half-maximum (FWHM) of post-deconvolution kernel ( $\mu\text{m}$ ). *{default: 240}*

**iter2** Number of post-deconvolution iterations. *{default: 15}*

### Expert parameters

Some adjustable parameters that can optimize the reconstruction results.

**stab\_option** Remove unstable frames (e.g., due to breathing/heartbeat). *{default: 1}*

**cutoff1** Low threshold for SVD filtering (range: 0–1). *{default: 0.25}*

**cutoff2** High threshold for SVD filtering (range: 0–1). *{default: 0.8}*

**BF\_option1** Enable additional background filtering. Note: Significantly reduces speed. *{default: 0}*

**finter1** First upsampling factor. Tips: Improves quality but reduces speed/increases memory.

Increase only with proportional reduction in fidelity/sparsity. *{default: 2}*

**FWHM1** FWHM of pre-deconvolution kernel ( $\mu\text{m}$ ). *{default: 180}*

**iter1** Number of pre-deconvolution iterations. *{default: 10}*

**hawk\_option** Enable HAWK processing. Note: Improves quality but increases memory usage. *{default: 0}*

**order** Autocorrelation order.

Tips: Higher values improve resolution but reduce image continuity/linearity. *{default: 6}*

**finter2** Second upsampling factor. *{default: 2}*

**fidelity\_z** Z-axis fidelity weight. Use 1 for isotropic data. *{default: 1}*

**BF\_option2** Secondary background filtering. Note: Significantly reduces speed. *{default: 0}*

Here are 4 examples:

```
[output_CEUS, output_deconv_n, output_deconv_p] =  
FLAME(input, 'pixel', 60, 'FWHM2', 330);  
[output_CEUS, output_deconv_n, output_deconv_p] =  
FLAME(input, 'MB_option', 1, 'fidelity', 10, 'sparsity', 1);  
[output_CEUS, output_deconv_n, output_deconv_p] =  
FLAME(input, 'SVD_option', 1, 'MB_option', 1, 'cutoff1', 0.1, 'cutoff2', 0.9);  
[output_CEUS, output_deconv_n, output_deconv_p] =  
FLAME(input, 'iter1', 5, 'iter2', 30);
```

## Fusion

Generate better quality intensity and flow velocity images using 4 ultra fast SR frames.

```
for k = 1:floor(size(data,4)/120)
[intensity_n, intensity_p, speed] = fusion(SR_volume_n(:,:,:(k-1)*4+1:(k-1)*4+4),SR_volume_p(:,:,:(k-1)*4+1:(k-1)*4+4));
end
```

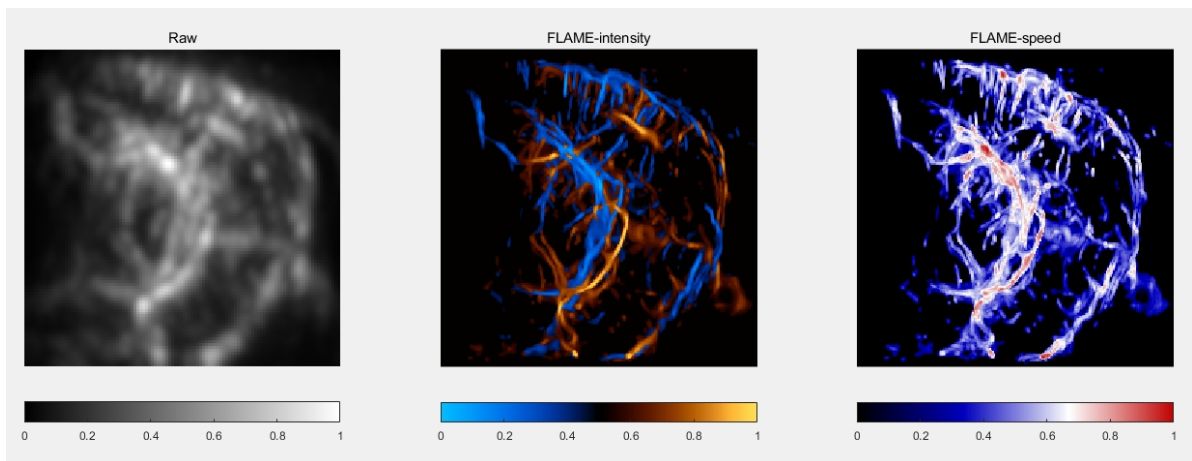
Rolling fusion can also be chosen to obtain fusion results with higher temporal resolution.

```
for k = 1:floor(size(data,4)/30)-3
[intensity_n, intensity_p, speed] =
fusion(SR_volume_n(:,:,k:k+3),SR_volume_p(:,:,k:k+3));
end
```

## Visualization

Use FLAME's specially designed color encoding to render the final result.

```
rendering(intensity_n, intensity_p, speed, output_CEUS,'MB_option',1);
```



You can also export a mat file containing the results and render it using other software.

## Declaration

This repository contains the MATLAB source code for **FLAME**.

## Open source [FLAMEm](#)

This software and corresponding methods can only be used for **non-commercial** use, and they are under Open Data Commons Open Database License v1.0.