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# Brain Stripping Magnetic Resonance Angiographic Images of Tumor-Bearing Mice

Paul Morel, Mark Van Horn, Francois Budin, Terry Van Dyke, Weili Lin, Elizabeth Bullitt

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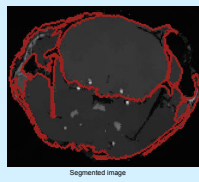
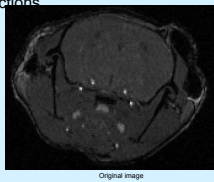
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## ABSTRACT

Brain stripping is a difficult task in mice with brain tumors. No group has described a fully effective method. We present a new method of defining the brain envelope from magnetic resonance angiographic (MRA) images of both healthy and tumor-bearing mice.

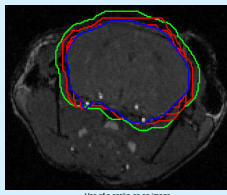
## BACKGROUND

❖ Mean shift segmentation [1] : determine the clusters by merging basins of attractions



- 3 parameters :
- $h_s$  : spatial domain
  - $h_r$  : range domain
  - $M$  : minimum number of pixel per region

❖ Snake [2] : active contour



- Snake of initialization
- Different steps of the snake
- Final Snake

Use of a snake on an image

## METHODS

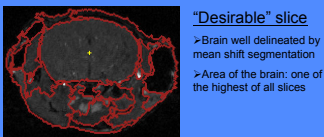
### Brain Stripping

#### ❖ Mean shift segmentation:

Based on 3 parameters :

- $h_s$  : spatial domain
- $h_r$  : range domain
- $M$  : minimum number of pixel per region

#### ❖ Choice "desirable" slice :



- "Desirable" slice
- Brain well delineated by mean shift segmentation
- Area of the brain: one of the highest of all slices

#### Choice

- Manually : find a "desirable" slice, select the region of the brain.
- Automatically :
  1. selection of 1 region on each
  2. Selection of 1 slice based on shape of the selected region and position of slice in the image.

#### ❖ Snake-based segmentation

- On the initial slice ("desirable" slice) :
  1. Initialization of the snake from the contour of the selected region.
  2. Determination of snake parameters automatically
  3. Run the snake until final snake to obtain the stripped brain of this slice
- Propagation of the snake throughout the image stake on a slice-by-slice basis
- On the other slices :
  1. Initialization of the snake from the final snake of the previous slice
  2. Determination of snake parameters automatically
  3. Run the snake until final snake to obtain the stripped brain of this slice

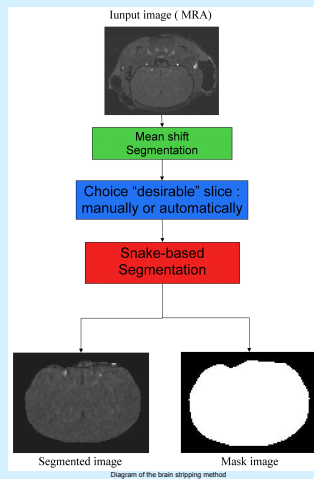


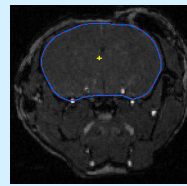
Diagram of the brain stripping method

## Results Evaluation

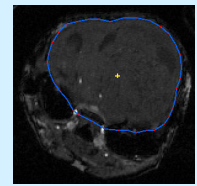
Evaluation : the gold standard a manual segmentation of the brain from each MRA image. We compared our results for both **speed** and **accuracy** to the semi-automated mode and the snake-based segmentation provided by ITK-Snap.

## RESULTS

### Examples of results obtained

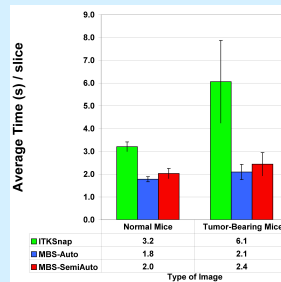


Segmented image of a normal mice

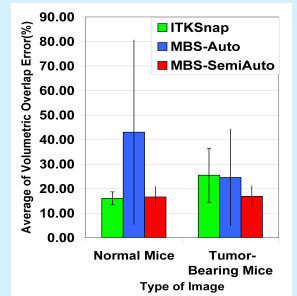


Segmented image of a tumor-bearing mice

### Results : speed

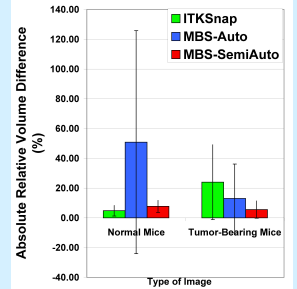


### Results : accuracy



### Statistical results : ITK-Snap [3] vs MBS-SemiAuto

P-value (MBS more accurate than ITK-Snap)	Speed	Error overlap	Volume difference
<b>Normal mice</b>	$1.10^{-5}$	Not significant	Not significant
<b>Tumor-bearing mice</b>	$9.10^{-11}$	$1.10^{-3}$	$1.10^{-3}$



## CONCLUSIONS

- ❖ Our method gives good results for brain stripping of MRA images of tumor-bearing mice
- ❖ The same approach could be employed for T1 or T2 images
- ❖ A fully automated approach is under development

## References:

- [1] Comaniciu, D., Meer, P.: Mean Shift : A Robust Approach Toward Feature Space Analysis. In: IEEE Transactions on pattern analysis and machine intelligence, Vol 24, No. 5, pp. 603-619 (2002).
- [2] Kass, M., Witkin, A., Terzopoulos, D.: Snakes:Active Contour Models. In: International Journal of Computer Vision, pp. 321-331 (1988).
- [3] Yushkevich, P.A, Piven, J., Hazlett, H. C., Smith R. G., Ho, S., Gee, J. C., Gerig, G.: User-guided 3D active contour segmentation of anatomical structures: Significantly improved efficiency and reliability. *Neuroimage* 2006 Jul 1;31(3):1116-28. [www.itksnap.org](http://www.itksnap.org)