Supervoxel Generation using GPU's

Team 01

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1 INTRODUCTION

Voxel based volumetric data is commonly used in medical imaging and environment understanding problems which involve classification and segmentation of voxels. However volumetric data is quite large which makes it computationally expensive to do tasks such as classification, segmentation and to store it. The same problem can be found in normal 2D images using pixels which is resolved by grouping together pixels of similiar intensity in a neighbourhood, these groupings are called superpixels.

Supervoxels are then analogous to superpixels but for voxel information with similar benefits. It is is thus beneficial to have supervoxel generation algorithms that are fast and efficient. This speedup can be achieved by parallelizing the algorithm on a GPU. .

2 LITERATURE REVIEW

There have been a few papers that have proposed different supervoxel generation algorithms, however the literature is quite sparse in this domain with most supervoxel based segmentation papers opting to use their own implementation of a supervoxel generator.

2.1 SLIC

This is an algorithm [3] for generating superpixels and shares a lot of similiarity with K-Means Clustering. The algorithm has a single parameter k denoting the number of approximately equally sized superpixels that have to be made. The cluster centers are initialised within uniform grids which are equally spaced apart. Next each pixel is assigned to the nearest cluster whose search space overlaps the pixel.New cluster centers are the computed and the process repeats till convergence. The distance metric used here takes into account both spacial and color proximity to compute distances.

2.2 ADASLIC

This method [4] is an extension of SLIC which attempts to take context of the structure of the voxels being clustered together in the supervoxel generation. This means that differently sized structures will have proportionally sized supervoxels. This is achieved using Poisson Disk sampling instead of uniform sampling like in SLIC. The source code has not been released by the authors nor is there any other implementation for the algorithm.

2.3 Supervoxel generation with a Anisotropic metric

This method [5] is also an extension of SLIC with the change being the metric that is used to calculate the distance between voxels. Their method is optimized for video data and use several concepts from that domain such as optical flow. Their algorithm is given in Figure 1. The authors have released the source code for this algorithm which runs on the GPU.

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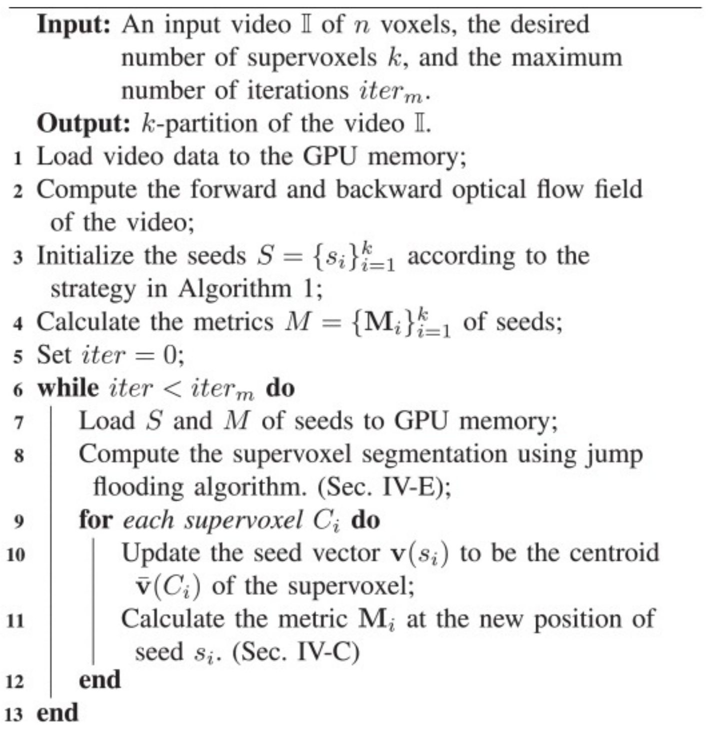

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Input: An input video $\mathbb{I}$ of $n$ voxels, the desired
       number of supervoxels $k$, and the maximum
       number of iterations $iter_m$.
Output: $k$-partition of the video $\mathbb{I}$.
1  Load video data to the GPU memory;
2  Compute the forward and backward optical flow field
     of the video;
3  Initialize the seeds $S = \{s_i\}_{i=1}^{k}$ according to the
     strategy in Algorithm 1;
4  Calculate the metrics $M = \{\mathbf{M}_i\}_{i=1}^{k}$ of seeds;
5  Set $iter = 0$;
6  while $iter < iter_m$ do
7      Load $S$ and $M$ of seeds to GPU memory;
8      Compute the supervoxel segmentation using jump
         flooding algorithm. (Sec. IV-E);
9      for each supervoxel $C_i$ do
10         Update the seed vector $\mathbf{v}(s_i)$ to be the centroid
             $\bar{\mathbf{v}}(C_i)$ of the supervoxel;
11         Calculate the metric $\mathbf{M}_i$ at the new position of
             seed $s_i$. (Sec. IV-C)
12     end
13 end
```

Fig. 1. Algorithm using the Anisotropic Metric [5]

2.4 RSLIc

It is a library [2] that supports generating superpixels and supervoxels for the corresponding input data.It implements the algorithms provided by EPFL.This does not a have a GPU based implementation.

2.5 gSLICr

It is [1] a GPU based library for superpixel generation that implements the SLIC algorithm on a GPU , however they have not provided an implementation for supervoxel generation.

3 MILESTONES

The aim of this project will be to implement the SLIC algorithm defined for generating superpixels and change it for generating supervoxels on a GPU.

S. No.	Milestone	Member
	Mid evaluation	
1	Modify the SLIC algorithm to work for supervoxels	Mortala Gautam Reddy
2	Implement SLIC on the CPU for voxel data	Mortala Gautam Reddy
3	Creating Structures to store the voxel grid	Mortala Gautam Reddy
4	Implement initialising cluster centers	Mortala Gautam Reddy
	Final evaluation	
5	Implement computation of distance metric	Mortala Gautam Reddy
6	Assignment of voxels to clusters	Mortala Gautam Reddy
7	Implementing the computation of new cluster centers	Mortala Gautam Reddy

4 APPROACH

4.1 Algorithmic Changes

The SLIC algorithm defined for creating superpixels could largely be implemented as it is with a few minor tweaks. The Grid Interval parameter which was $\sqrt{N/K}$ *became* $\sqrt[3]{N/K}$ *to account for the fact that the search space is a volume instead of an area. Another change that was made to ensure correctness was to remove the gradient computation and perturbing the initialised cluster centers. The clusters generated seem to be still correct and this will be added later on.*

4.2 Code Implementation

- Repeat iter times
- Iterate over every cluster centre
- iterate over all voxels in the search space of the cluster centre
- Check if a voxel has been visited
- if it has not then loop over all the cluster centres
- check if the cluster centre is within the search space of the outer loop's cluster centre
- compute distance metric if above condition is true
- Find the smallest distance and the corresponding cluster index and assign the voxel to that cluster
- Check for any unvisited voxels
- if there exist such voxels assign them to the closest cluster
- assign cluster indexes as the voxel values
- dump the grid into a binary file

The visited array was required here to ensure that the same voxel did not get added multiple times to a cluster. This was happening because a voxel can lie in the search space of multiple cluster centers and its closest cluster centre will also be present in those search spaces leading to the extraneous counting.

4.3 Challenges

The sampling of cluster centers currently does not match the number of supervoxels specifed at the start of the program. Unless [N/K] results in a perfect cube , it seems that this discrepancy will arise.

Since the nhdr header states that the datatype of the value stored in the voxel grid is unsigned char , that means there cannot be more that 255 clusters or supervoxels for such grids.There were some problems with visualising a segment map of the voxel grid as well in Slicer3D.

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5 RESULTS

We have provided the original voxel grids and the modified voxel grids visualised in Slicer3D. .

The modified voxel appears to have had more voxels introduced , this is due to these voxels having an intensity of 0 in the original grid which has been increased due to their value now indicating the supervoxel they now belong to . .

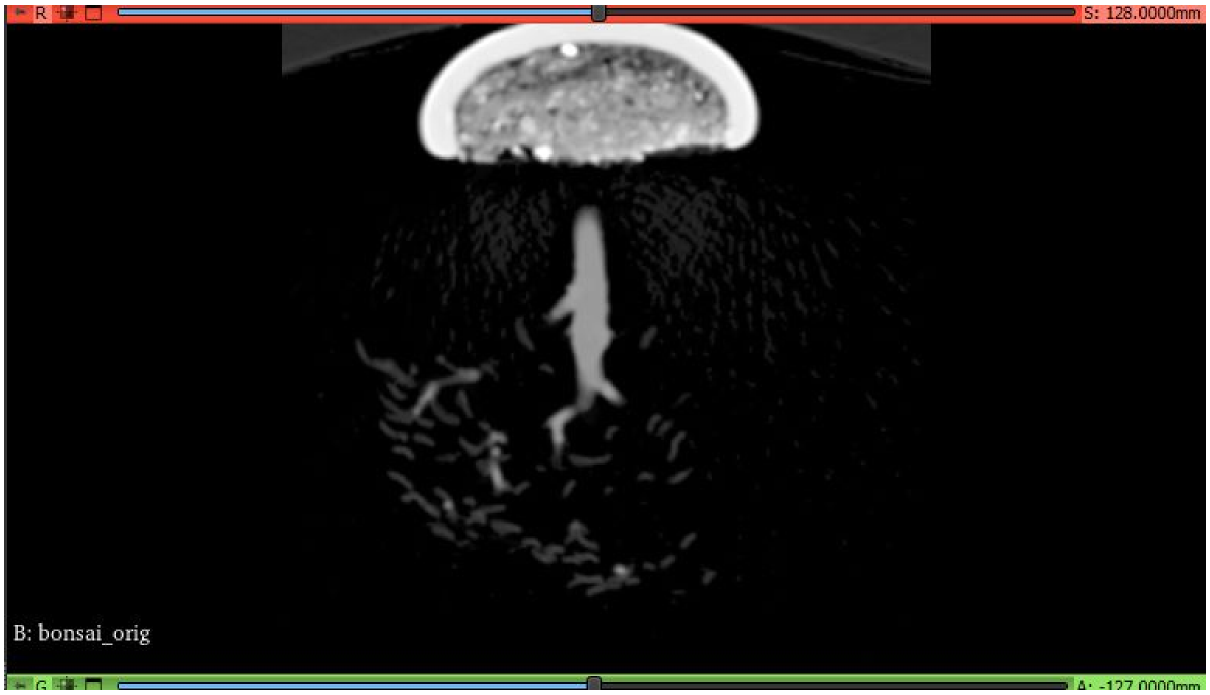

Fig. 2. One View of the original voxel grid

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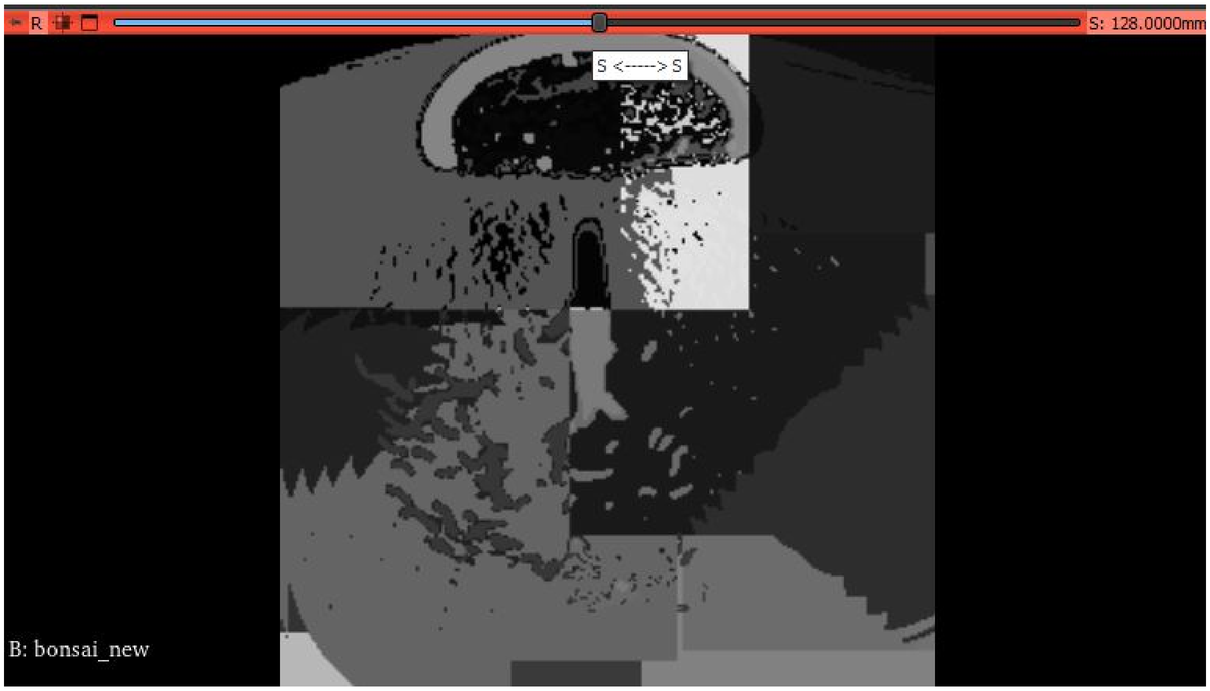

Fig. 3. One View of the modified voxel grid