Local Binary Pattern

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Overview

Sequential LBP

Parallel

CUDA

Results

Sequential LBP

LBP

- The Local Binary Pattern is an image descriptor
- Used mainly in texture analysis
- Computational simplicity

LBP

- For each pixel define a neighborhood centered in the current pixel
- Compare pixels' values
- Define a new binary value for the current pixel

Implementation

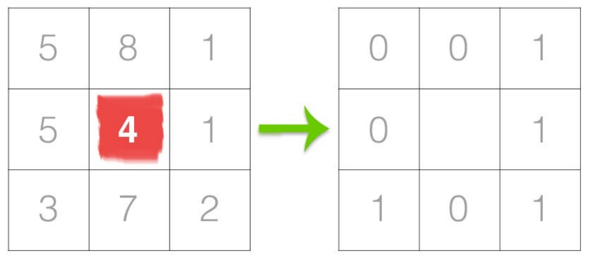
The LBP descriptor for every pixel is given as:

$$LBP(P,R) = \sum_{p=0}^{p-1} f(g_c - g_p)2^p$$

where g_c and g_p denote the intensity of the current and neighboring pixel, respectively. To the negative differences is assigned 0, to the positives is assigned 1.

The parameters of the algorithm are the number P of pixels to use for the LBP descriptor, R the radius of the neighborhood.

LBP



Example of LBP step

MultiBlock

- Different approach for facial image representation
- The image is divided into local regions
- Use local descriptions for each region and combine them into a global description

Implementation

Algorithm 1 LBP Sequential

```
for each pixel i in I do
    DefineNeighborhood(i, P, R);
    ComputeLBP(i, P)
    UpdateHistogram
```

Parallel

Parallel C++

- Use multiblock approach
- Divide between threads the input
- Each thread computes LBP on a part of input pixels
- No synchronization needed

Implementation

Algorithm 2 Parallel LBP

1: **for** $t < num\_threads$ **do**
2: LBPThread (P, R)
3: ComputeHistogram

Algorithm 3 LBP Thread

1: **for** each pixel i **do**
2: DefineNeighborhood(i, P, R);
3: ComputeLBP(i, P)
4: UpdateHistogram

CUDA

CUDA

- The multi-block approach exploits CUDA architecture
- Each block of threads corresponds to a sub-region of the image
- Each block computes LBP for its corresponding region

CUDA

- Each thread computes LBP for a single pixel
- Then updates the local histogram
- `AtomicAdd` is used to avoid race condition

Implementation

Algorithm 4 Kernel LBP

for each thread in block **do**
    $position \leftarrow threadId + blockId * blockEdge$
    $pixel \leftarrow$ GetPixel($position$)
    $vectorP \leftarrow$ LBPvalue($pixel$)
    atomicAdd($histogram, vectorP$)

Results

Context

- The performances are measured by evaluating the speedup
- Changing the parameters and using different input sizes
- Using Microsoft Azure Virtual Machine with Intel Xeon E5-2690 v3 @ 2.60GHz, 6 cores and NVIDIA Tesla M60.

Results

Size	Sequential	CUDA	SpeedUp
(750x562)	109 ms	4 ms	27.25
(1000x750)	195 ms	7 ms	27.85
(1500x1125)	445 ms	15 ms	29.66
(2000x1500)	779 ms	27 ms	28.85
(3000x2000)	1729 ms	61 ms	28.34
(4000x3000)	3039 ms	107 ms	28.40

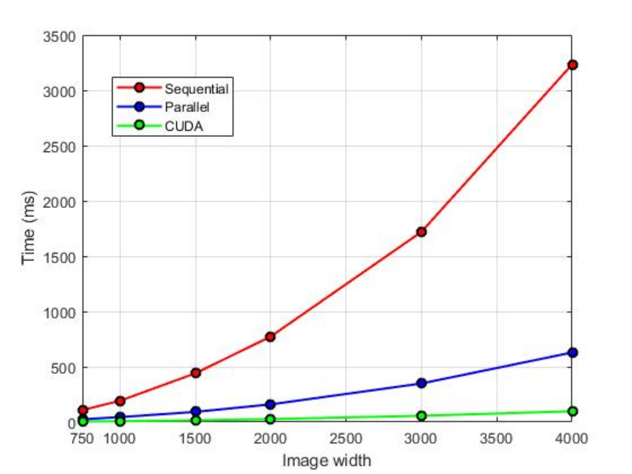
Tabelle 1: Comparison between sequential and CUDA

Results

Size	Parallel	CUDA	SpeedUp
(750x562)	24 ms	4 ms	6.00
(1000x750)	42 ms	7 ms	6.00
(1500x1125)	96 ms	15 ms	6.40
(2000x1500)	161 ms	27 ms	5.96
(3000x2000)	356 ms	61 ms	5.83
(4000x3000)	626ms	107 ms	5.85

Tabelle 2: Comparison between parallel and CUDA.

Results



Performance comparison with different image sizes

Results

Parameters	Sequential	CUDA	SpeedUp
P=15, R=2, e=32	5069 ms	1004 ms	5.05
P=14, R=2, e=32	3885 ms	514 ms	7.56
P=13, R=2, e=32	3237 ms	264 ms	12.26
P=12, R=2, e=32	2866 ms	139 ms	20.62
P=11, R=2, e=32	2552 ms	76 ms	33.58
P=10, R=2, e=32	2299 ms	45 ms	51.09
P=9, R=2, e=32	2084 ms	27 ms	77.19
P=8, R=2, e=32	1926 ms	18 ms	107.00
P=6, R=2, e=32	1592 ms	10 ms	159.20
P=4, R=2, e=32	1297 ms	7 ms	185.29

Tabelle 3: Comparison between sequential and CUDA, size (3840x2160)

Results

Parameters	Parallel	CUDA	SpeedUp
P=15, R=2, e=32	2468 ms	1004 ms	2.24
P=14, R=2, e=32	1442 ms	514 ms	2.81
P=13, R=2, e=32	907 ms	264 ms	3.44
P=12, R=2, e=32	646 ms	139 ms	4.65
P=11, R=2, e=32	502 ms	76 ms	6.61
P=10, R=2, e=32	408 ms	45 ms	9.07
P=9, R=2, e=32	349 ms	27 ms	12.93
P=8, R=2, e=32	318 ms	18 ms	17.67
P=6, R=2, e=32	261 ms	10 ms	26.10
P=4, R=2, e=32	213 ms	7 ms	30.43

Tabelle 4: Comparison between parallel and CUDA, image size (3840x2160)

END