ECE 4310: Intro to Computer Vision
Sarah Anderson
Lab 1: Convolution, separable filters, sliding windows
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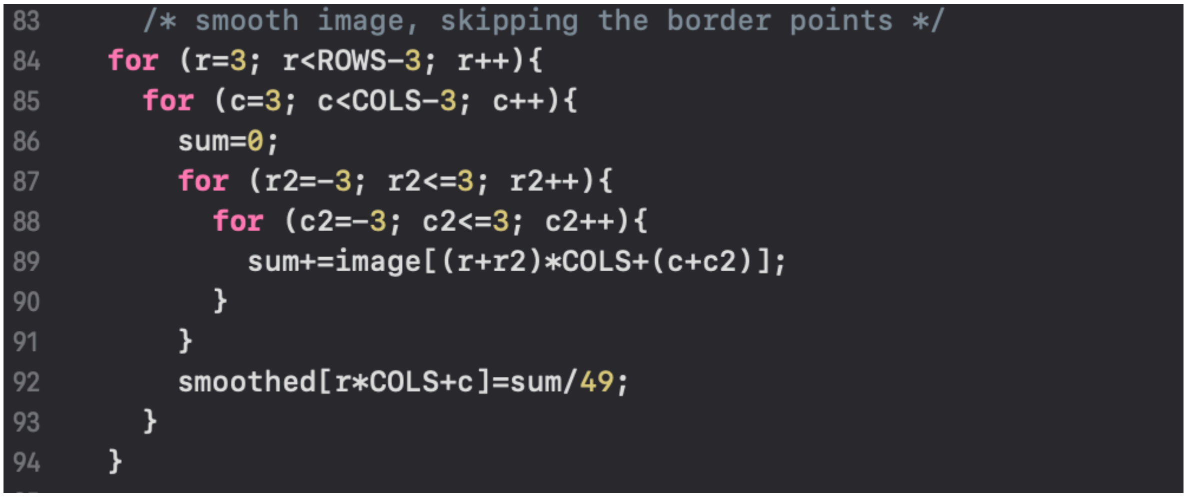
Purpose:
The purpose of this lab is to create three separate filters: a normal 7x7 convolution, a separable filter (one 1x7 filter and one 7x1 filter), and a sliding window filter (a separable filter with a sliding 7x7 window).

Results:

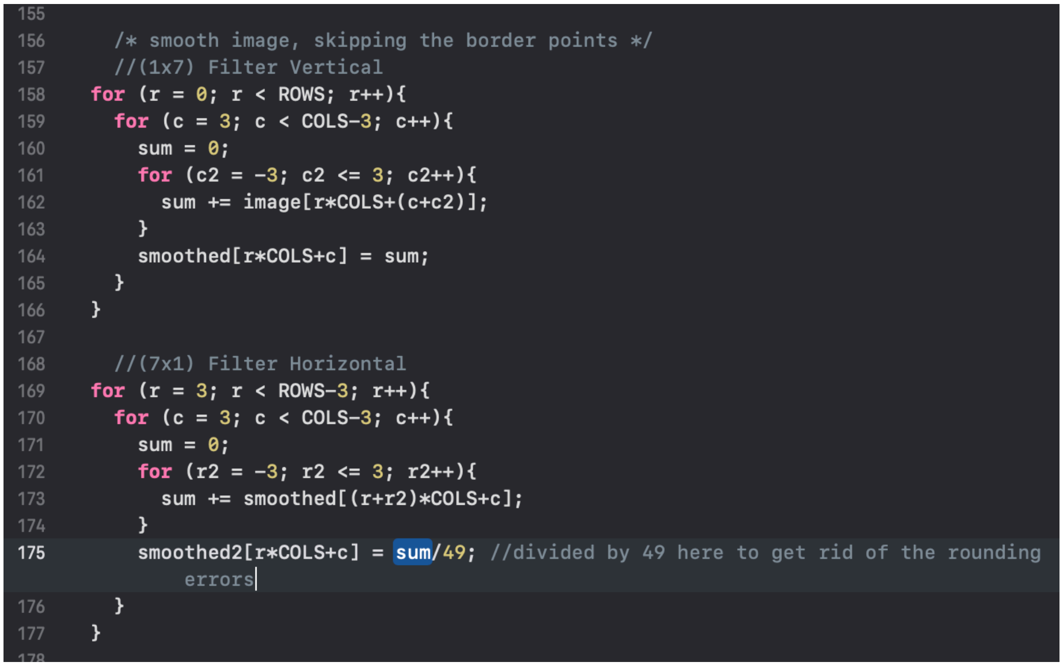
	Run 1 (ns)	Run 2 (ns)	Run 3 (ns)	Run 4 (ns)	Run 5 (ns)	Run 6 (ns)	Run 7 (ns)	Run 8 (ns)	Run 9 (ns)	Run 10 (ns)	Average (ns)
Standard	38540000	40056000	40542000	38203000	39403000	39561000	32919000	46427000	39437000	37397000	**39248500**
Separable	11665000	12082000	12150000	11739000	11573000	11216000	10590000	9317000	12388000	11365000	**11408500**
Sliding	5916000	5469000	4992000	4749000	7767000	4711000	4554000	4436000	5615000	6648000	**5485700**

Standard 7x7 Convolution Filter Code:



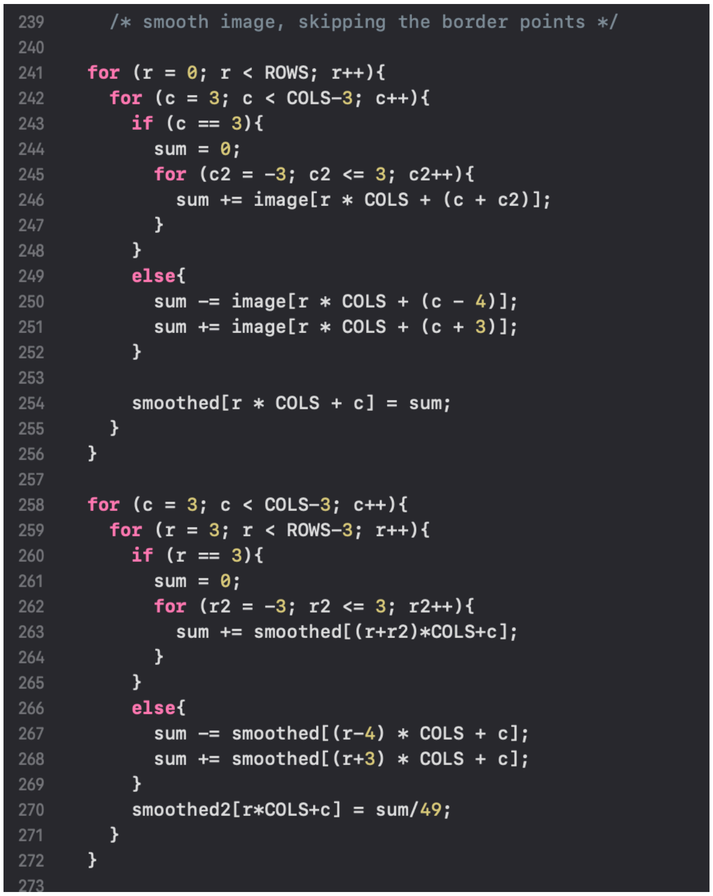
```
  /* smooth image, skipping the border points */
for (r=3; r<ROWS-3; r++){
  for (c=3; c<COLS-3; c++){
    sum=0;
    for (r2=-3; r2<=3; r2++){
      for (c2=-3; c2<=3; c2++){
        sum+=image[(r+r2)*COLS+(c+c2)];
      }
    }
    smoothed[r*COLS+c]=sum/49;
  }
}
```

Separable Filter Code:



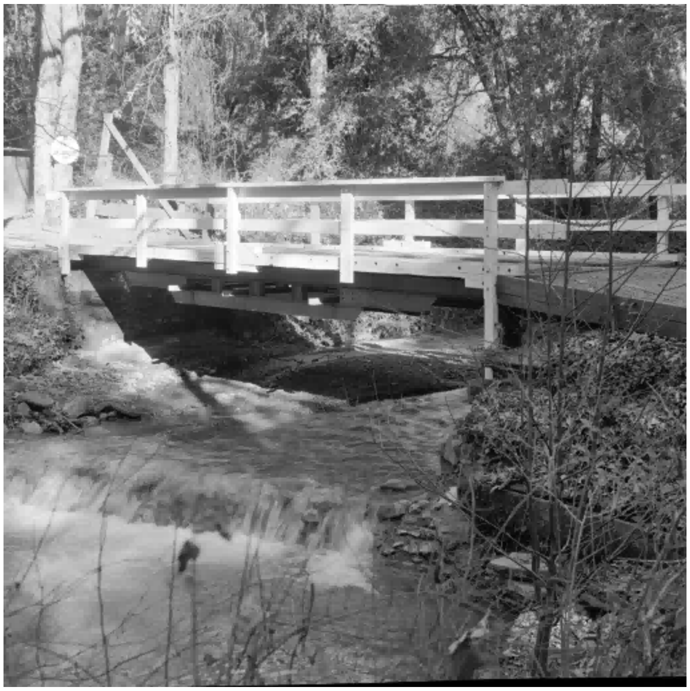
```
  /* smooth image, skipping the border points */
  //(1x7) Filter Vertical
for (r = 0; r < ROWS; r++){
  for (c = 3; c < COLS-3; c++){
    sum = 0;
    for (c2 = -3; c2 <= 3; c2++){
      sum += image[r*COLS+(c+c2)];
    }
    smoothed[r*COLS+c] = sum;
  }
}

  //(7x1) Filter Horizontal
for (r = 3; r < ROWS-3; r++){
  for (c = 3; c < COLS-3; c++){
    sum = 0;
    for (r2 = -3; r2 <= 3; r2++){
      sum += smoothed[(r+r2)*COLS+c];
    }
    smoothed2[r*COLS+c] = sum/49; //divided by 49 here to get rid of the rounding errors
  }
}
```

Sliding Filter Code:

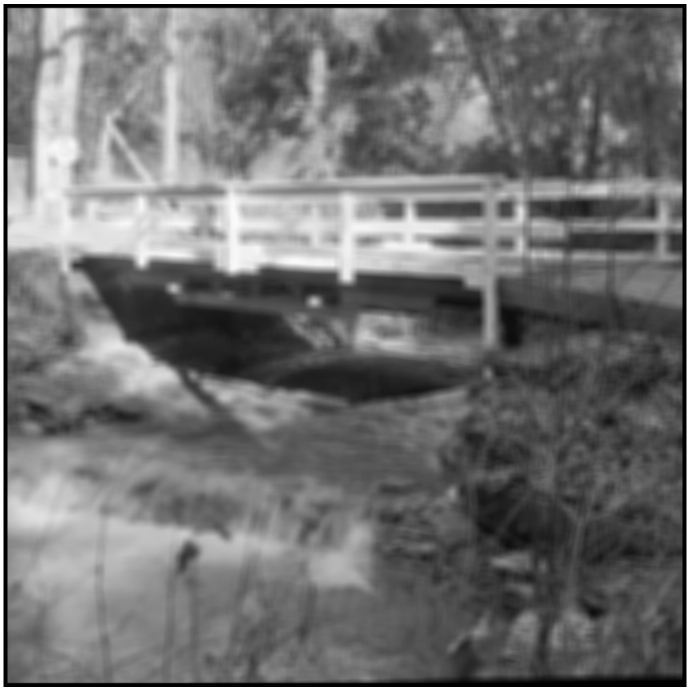


```
  /* smooth image, skipping the border points */

for (r = 0; r < ROWS; r++){
  for (c = 3; c < COLS-3; c++){
    if (c == 3){
      sum = 0;
      for (c2 = -3; c2 <= 3; c2++){
        sum += image[r * COLS + (c + c2)];
      }
    }
    else{
      sum -= image[r * COLS + (c - 4)];
      sum += image[r * COLS + (c + 3)];
    }

    smoothed[r * COLS + c] = sum;
  }
}

for (c = 3; c < COLS-3; c++){
  for (r = 3; r < ROWS-3; r++){
    if (r == 3){
      sum = 0;
      for (r2 = -3; r2 <= 3; r2++){
        sum += smoothed[(r+r2)*COLS+c];
      }
    }
    else{
      sum -= smoothed[(r-4) * COLS + c];
      sum += smoothed[(r+3) * COLS + c];
    }
    smoothed2[r*COLS+c] = sum/49;
  }
}
```

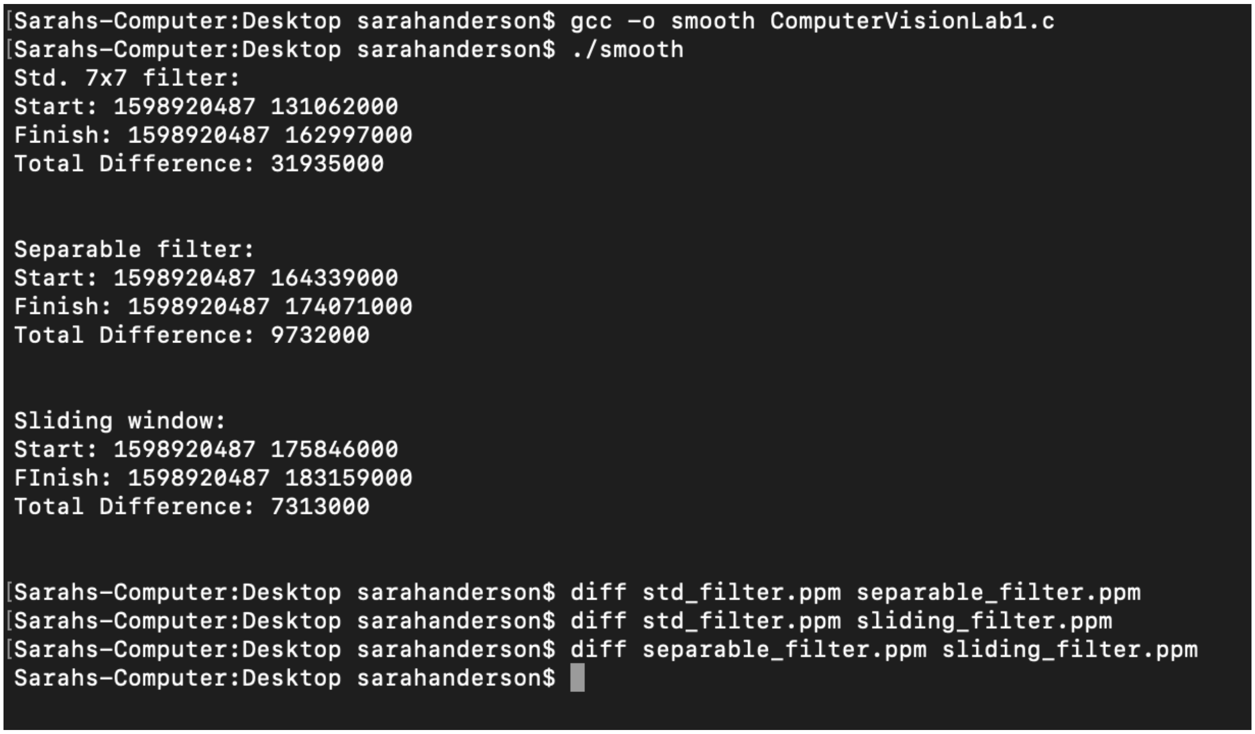
Original Image:



Smoothed Image:



Example of output and diff commands:



```
[Sarahs-Computer:Desktop sarahanderson$ gcc -o smooth ComputerVisionLab1.c
[Sarahs-Computer:Desktop sarahanderson$ ./smooth
Std. 7x7 filter:
Start: 1598920487 131062000
Finish: 1598920487 162997000
Total Difference: 31935000


Separable filter:
Start: 1598920487 164339000
Finish: 1598920487 174071000
Total Difference: 9732000


Sliding window:
Start: 1598920487 175846000
FInish: 1598920487 183159000
Total Difference: 7313000


[Sarahs-Computer:Desktop sarahanderson$ diff std_filter.ppm separable_filter.ppm
[Sarahs-Computer:Desktop sarahanderson$ diff std_filter.ppm sliding_filter.ppm
[Sarahs-Computer:Desktop sarahanderson$ diff separable_filter.ppm sliding_filter.ppm
Sarahs-Computer:Desktop sarahanderson$ 
```

Conclusion:
The results above were as expected; the standard 7x7 filter was the slowest, the separable filter was in the middle and the sliding filter was the fastest. The different filter speeds changed due to the amount of calculations needed to “smooth” the image. The most calculations was the standard 7x7 convolution filter and the least amount of calculations was the sliding filter. The three-pixel black edge on the smoothed picture is caused by zeros being added when it was off of the image. To reduce this edge, you would need a smaller matrix, but with a smaller matrix, you wouldn’t get an as smooth image. As shown above using the diff command, the smoothed images produced with three different types of filter is the same result each time just the time that it takes differs.