

Assignment MPI: Circuit Satisfiability

Parallel and Grid Computing Lecture

Ivan Tishchenko

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Exercise 1. Pi computation using trapezium rule

1. $f''(x) = \frac{8(3x^2 - 1)}{(1 + x^2)^3}$

global maximum M is 2, when $x = \pm 1$

Global maxima:

$$\max\left\{\frac{8(3x^2 - 1)}{(x^2 + 1)^3}\right\} = 2 \text{ at } x = -1$$

$$\max\left\{\frac{8(3x^2 - 1)}{(x^2 + 1)^3}\right\} = 2 \text{ at } x = 1$$

Plot

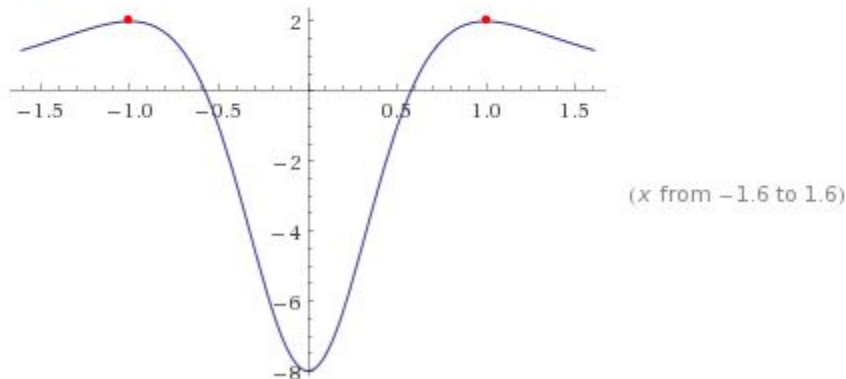


Figure 1: Global maximum

Thus the error $\epsilon \leq \frac{11}{66n^2}$

2. please find the solution **pi_1.c**

```
C:\Windows\System32\cmd.exe

D:\HPC\PI\build\Debug>pi_1.exe
Intervals: 1000
Calculated PI = 3.14159273692312269, Error is 0.00000008333332957
```

3. please find the solution **pi_2.c**

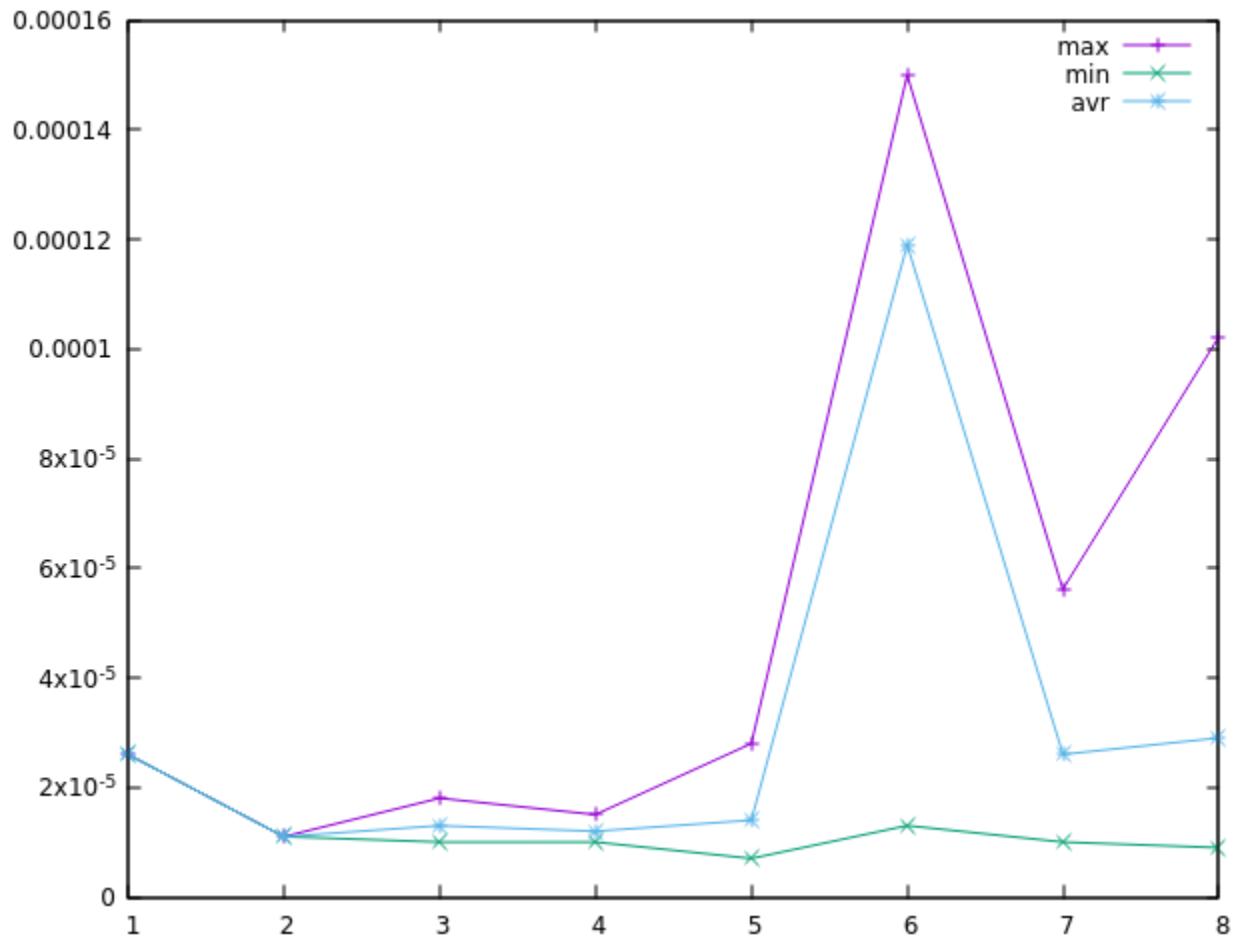
```
C:\Windows\System32\cmd.exe

D:\HPC\PI\build\Debug>mpiexec -n 4 pi_2.exe
[Node 0] Intervals: 1000
[Node 0] Calculated PI = 3.14159273692312668, Error is 0.00000008333333357
```

- (a) Partitioning – compute the chunk based on processes ID
 - (b) Communication – process 0 broadcasts the number of intervals to the others, the value of pi itself is reduced at the end
 - (c) Agglomeration – the algorithm has a parallel nature
 - (d) Mapping – try to map the tasks proportionally to cores computing abilities.
4. please find the solution **pi_3.c**
The time estimates and a graph are also attached.

```
C:\Windows\System32\cmd.exe

D:\HPC\PI\build\Debug>mpiexec -n 4 pi_3.exe
[Node 0] Intervals: 1000
[Node 0] Calculated PI = 3.14159273692312668, Error is 0.00000008333333357
[Node 0] Elapsed time: 0.000532 s
[Node 0] Elapsed time MAX: 0.000532 s
[Node 0] Elapsed time MIN: 0.000326 s
[Node 0] Elapsed time AVG: 0.000413 s
```



Exercise 2. Pi computation using Simpson's rule

1. please find the solution **sim_1.c**

```

C:\Windows\System32\cmd.exe

D:\HPC\PI\build\Debug>sim_1.exe
Intervals: 100
Calculated PI = 3.14159265358979489, Error is 0.00000000000000178

```

2. please find the solution **sim_2.c**

The methodology is identical to the previous problem

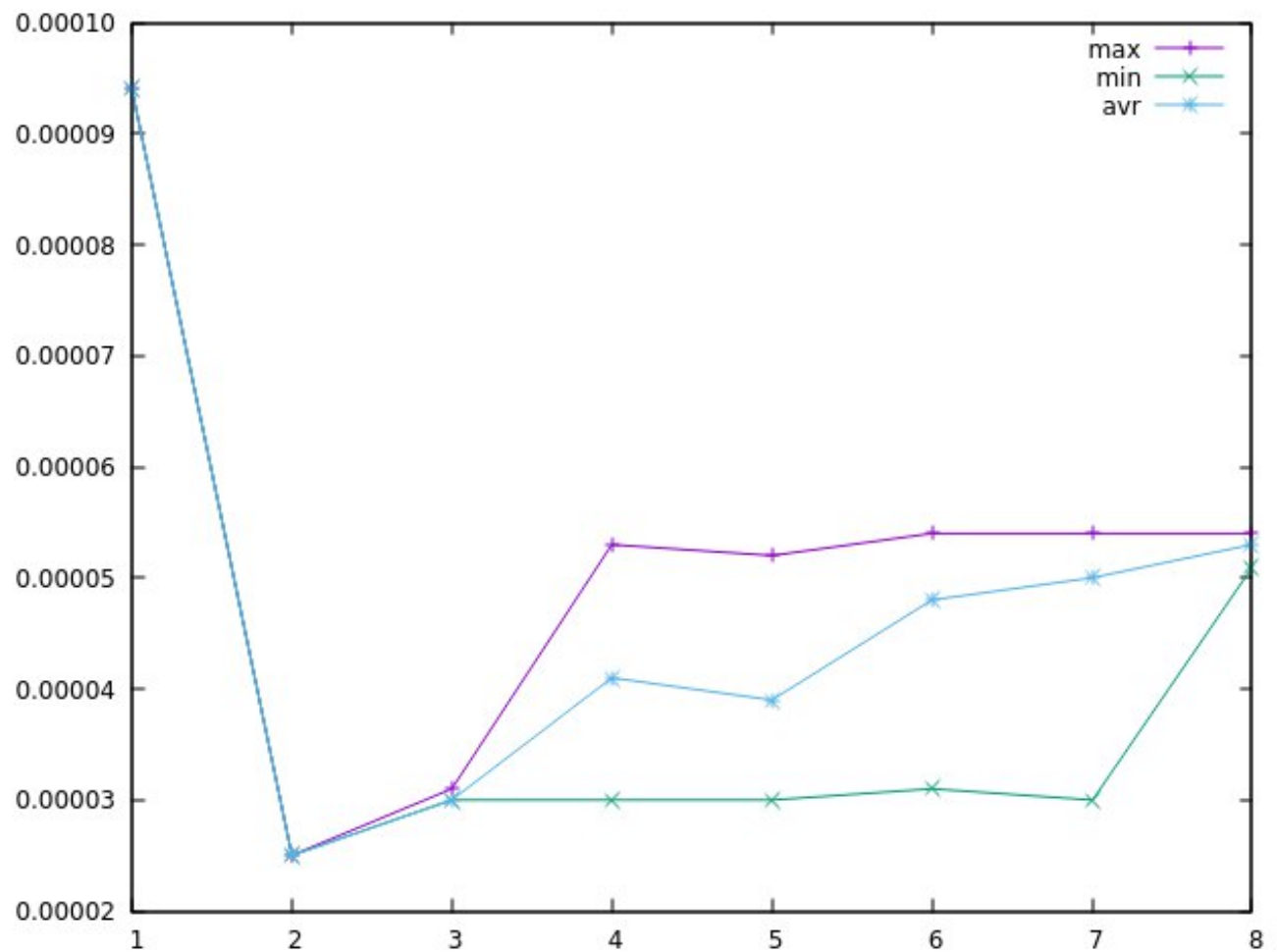
```
C:\Windows\System32\cmd.exe

D:\HPC\PI\build\Debug>mpiexec -n 4 sim_2.exe
[Node 0] Intervals: 10
[Node 0] Calculated pi 3.1415926535896417
Error is 0.0000000000001514
```

3. please find the solution **sim_3.c**
The time estimates and a graph are also attached

```
C:\Windows\System32\cmd.exe

D:\HPC\PI\build\Debug>mpiexec -n 4 sim_3.exe
[Node 0] Intervals: 10
[Node 0] Calculated pi 3.1415926535896417
Error is 0.0000000000001514
[Node 0] Elapsed time MAX: 0.000004 s
[Node 0] Elapsed time MIN: 0.000003 s
[Node 0] Elapsed time AVG: 0.000003 s
```



Exercise 3. Pi computation using Monte-Carlo rule

1. please find the solution **mc_1.c**

```

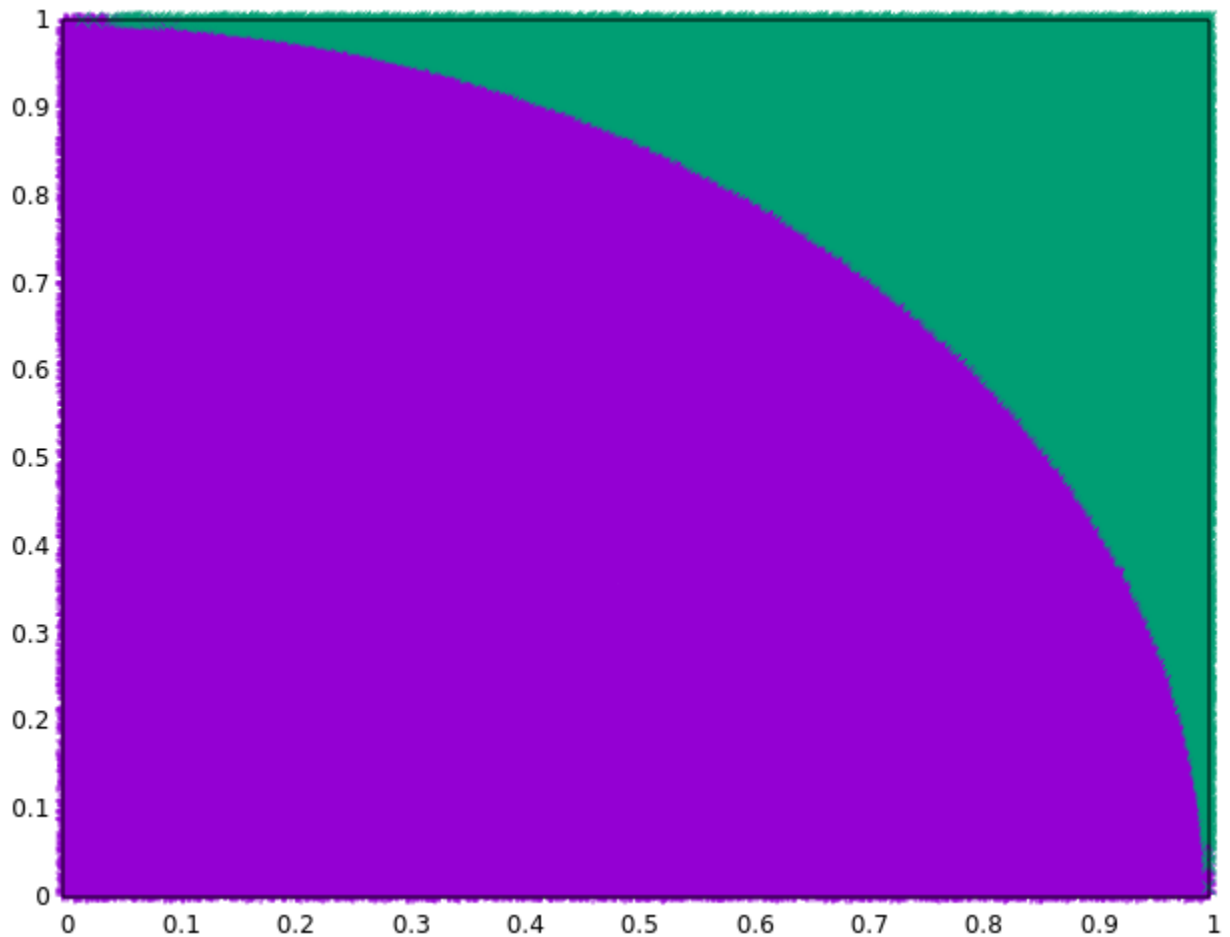
C:\Windows\System32\cmd.exe
D:\HPC\PI\build\Debug>mc_1.exe
Calculated PI = 3.1434240000000000, Error is 0.00183134641020688

```

2. please find the solution **mc_2.c**

The image of PI Approximation with two classes of points.

```
C:\Windows\System32\cmd.exe
D:\HPC\PI\build\Debug>mc_2.exe
Calculated PI = 3.1434240000000000, Error is 0.00183134641020688
```



3. please find the solution **mc_3.c**

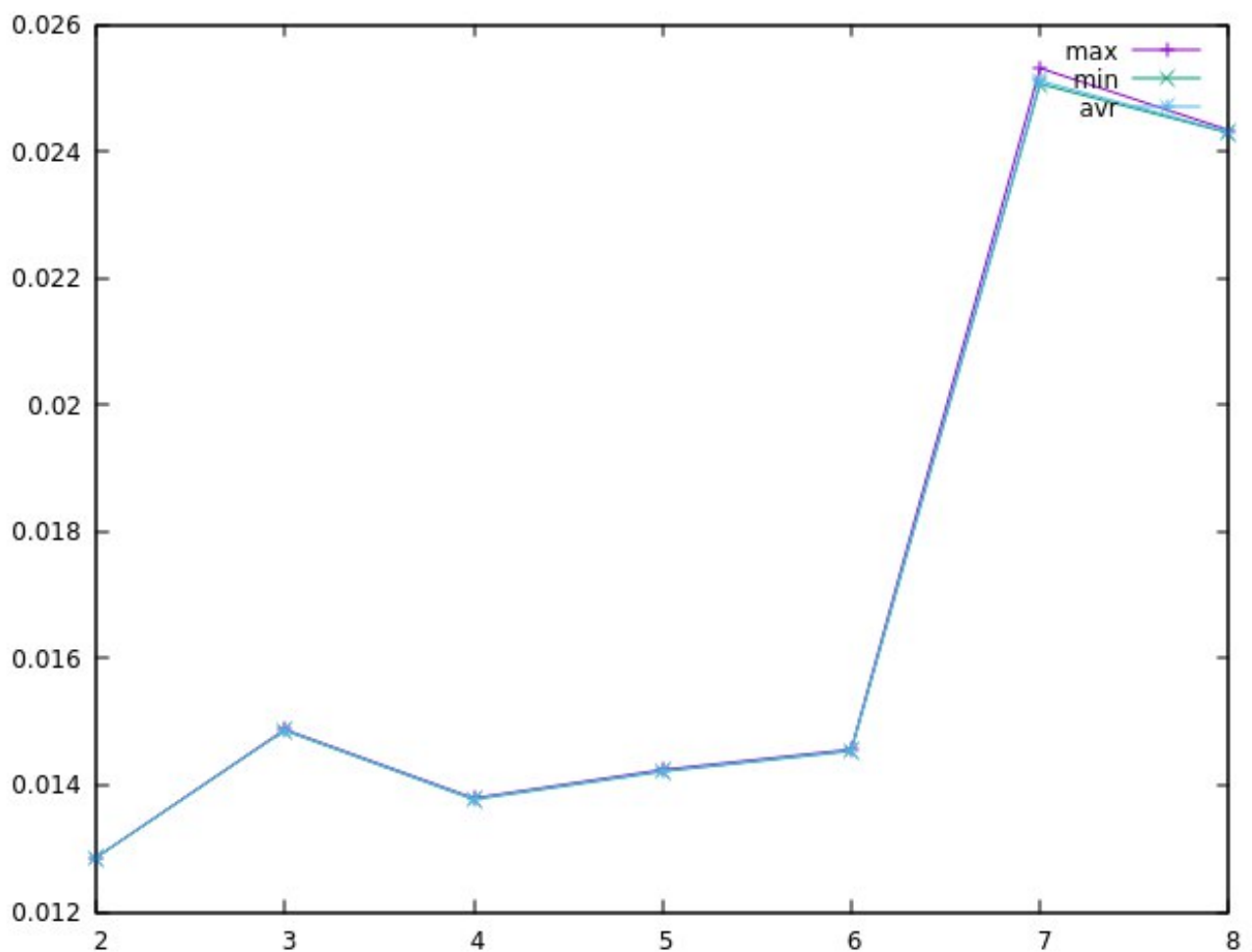
4. please find the solution **mc_3.c**

```
C:\Windows\System32\cmd.exe
D:\HPC\PI\build\Debug>mpiexec -n 4 mc_3.exe
Calculated PI = 3.13786826347305370, Error is 0.00372439011673942
```

5. please find the solution **mc_4.c**
Time graphs are:

```
C:\Windows\System32\cmd.exe

D:\HPC\PI\build\Debug>mpiexec -n 4 mc_4.exe
Calculated PI = 3.15161676646706601, Error is 0.01002411287727289
[Node 0] Elapsed time MAX: 2.709514 s
[Node 0] Elapsed time MIN: 2.709354 s
[Node 0] Elapsed time AVG: 2.709463 s
```



References

- [1] Sbastien Varrette. *The Lecture slides*.