

CS 6230/5960
Programming Assignment 1
Due Friday, 1/31/2020, 11:59pm

For this programming assignment, you are to perform loop transformations to improve the performance of each of the following codes, for sequential execution on one core. Experimental results should be presented for execution on one core of a node on a CHPC system (batch script will be provided for the execution).

Template codes (pa1-p1.c, pa1-p2.c, pa1-p3.c) will be provided for each problem, with a base code and a second copy of the code that you should modify. A comparison of results from the baseline and the modified code will also be automatically performed by the provided template code and any differences reported. You may make any changes to the codes to improve performance, as long as the correctness tests pass.

1. (35 points) In some applications, there is a need to perform two matrix-vector products: $z = Ax$ as well as $y = A^T x$. The following code shows one way to implement it. But its performance is much less than desired. Perform loop transformations to improve performance (target performance will be provided).

```
double x[N], y[N], z[N], A[N][N]; int i, j;
for (i=0; i<N; i++)
  for (j=0; j<N; j++)
  {
    y[j]=y[j]+A[i][j]*x[i];
    z[j]=z[j]+A[j][i]*x[i];
  }
```

2. (30 points) In the following code, the sum of squares of elements is needed along the middle dimension of a 3D array. Make changes to improve performance (target performance will be provided).

```
int i, j, k;
double sum, x[N][N][N], y[N][N];
for (i=0; i<n; i++)
  for (k=0; k<n; k++)
  {
    sum = 0.0;
    for (j=0; j<n; j++) sum += x[i][j][k]*x[i][j][k];
    y[i][k]=sum;
  }
```

3. (35 points) The following code performs the product $A^T B^T$. Use loop transformations to improve performance. (target performance will be provided).

```
int i, j, k;
double A[N][N], B[N][N], C[N][N];
for (i=0; i<n; i++)
  for (j=0; j<n; j++)
    for (k=0; k<n; k++)
      C[i][j] += A[k][i]*B[j][k];
```

Present results with the GNU gcc compiler (gcc -O3). Submit a detailed report explaining the main reason for low performance of the provided reference version, what you did to improve performance, and the improvements achieved.

Upload your source code for each problem, with suitable comments in the source code.