Optimizing Gemm Step 1

This Live Script helps you visualize the performance of the implementation of matrix-matrix multiplication casted as Gemv operations in GemmJPI_Gemv.c.

To gather the performance data, execute

```
clear

system('make test_GemmJI_Kernel_MRxNR')
```

```
echo "3 32 1000 32" | ./driver_GemmJI_Kernel_MRxNR.x > output_data_GemmJI_Kernel_MRxNR.m
ans = 0
```

When completed, this creates output file 'output_data_GemmPJI_Ger.m' with timing data. This Life Script then creates graphs from that timing data.

Step 1a: Load timing data

```
output_data_GemmJI_Kernel_MRxNR
```

Step 1b: Make sure you are getting the right answer

In output_data_GemmJPI_Gemv.m, for each execution of GemmJPI_Gemv, timing data is collected as well as how close the answer is to the answer attained by the reference implementation. Here we look at the maximum difference over all experiments. This should be somewhere on the order of $ 10^{-11} $ or smaller. Notice that you can expect some difference between the two implementations, due to round-off error and the order in which computations are performed.

```
MaxAbsDiff = max( abs( data_GemmJI_Kernel_MRxNR( :, 3 ) ) )
```

```
MaxAbsDiff = 1.0232e-12
```

```
if ( MaxAbsDiff > 1.0e-10 )
    disp( 'Hmmm, better check if there is an accuracy problem' );
else
    disp( 'It appears all is fine' );
end
```

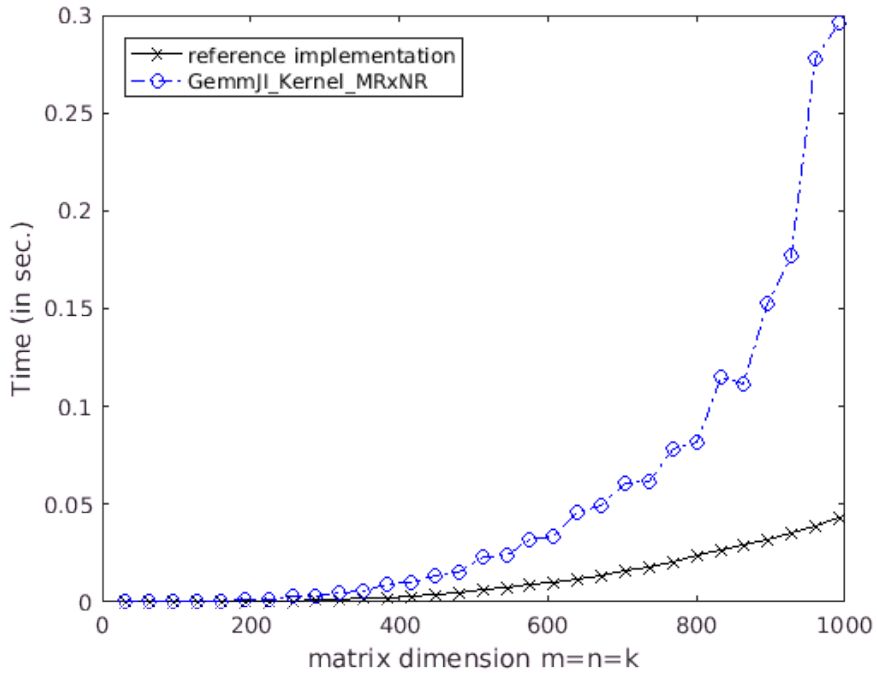
```
It appears all is fine
```

Step 1c: Plot the timing data.

The first graph shows the execution time of the different implementations as a function of the matrix size n.

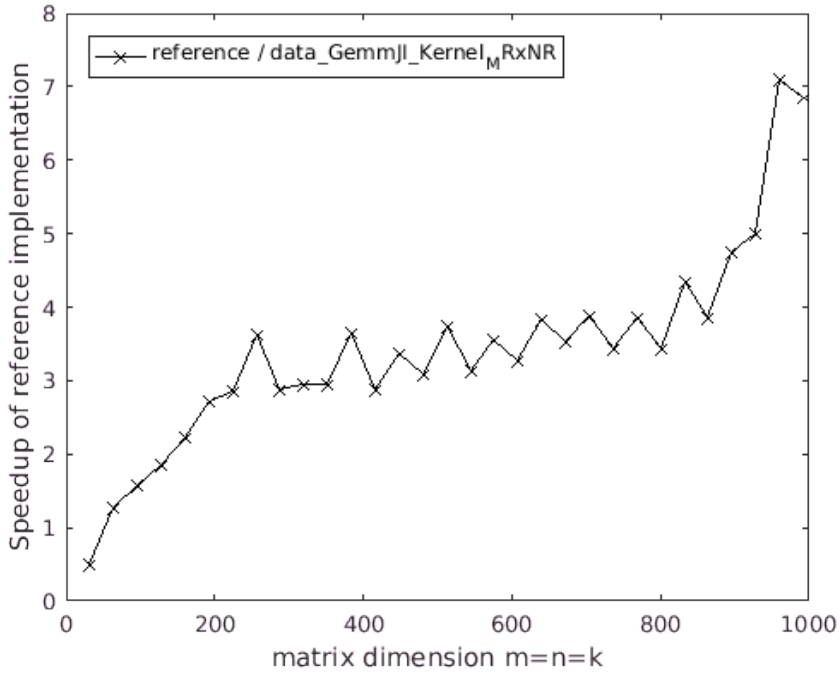
```
close all

% Plot the reference implementation performance
plot( data_ref( :,1 ), data_ref( :, 2 ), 'k-x' );

hold on    % Plot additional data in same figure
```

```
plot( data_GemmJI_Kernel_MRxNR( :,1 ), data_GemmJI_Kernel_MRxNR( :, 2 ), 'b-.o' );

hold off   % Stop plotting additional data in same figure% Plot additional data in same figure

% Add x- and y-axis labels and legend
xlabel( 'matrix dimension m=n=k' );
ylabel( 'Time (in sec.)' );
legend( 'reference implementation', ...
        'GemmJI\_Kernel\_MRxNR', ...
        'Location', 'NorthWest' );

% Adjust the x axis
v = axis;     % extract the current ranges
axis( [ 0 v(2) 0 v(4) ] )  % start the x axis and y axis at zero
```



Notice that the reference implementationis considerably faster than the implmentation of "triple loop" IJP using the Axpy subroutine. We illustrate that by plotting the speedup of the highly optimized reference implementation relative to GemmIPJ_Axpy.

```
plot( data_ref( :,1 ), data_GemmJI_Kernel_MRxNR( :, 2 ) ./ data_ref( :, 2 ), 'k-x' );

hold on    % Plot additional data in same figure

hold off   % Stop plotting additional data in same figure% Plot additional data in same figure

% Add x- and y-axis labels and legend
xlabel( 'matrix dimension m=n=k' );
ylabel( 'Speedup of reference implementation' );
legend( 'reference / data\_GemmJI\_Kernel_MRxNR', ...
        'Location', 'NorthWest' );

% Adjust the x axis
v = axis;     % extract the current ranges
axis( [ 0 v(2) 0 v(4) ] )  % start the x axis and y axis at zero
```



Step 3: Plot performance.

We often view the rate at which routines compute rather than the time required for completing the computation.

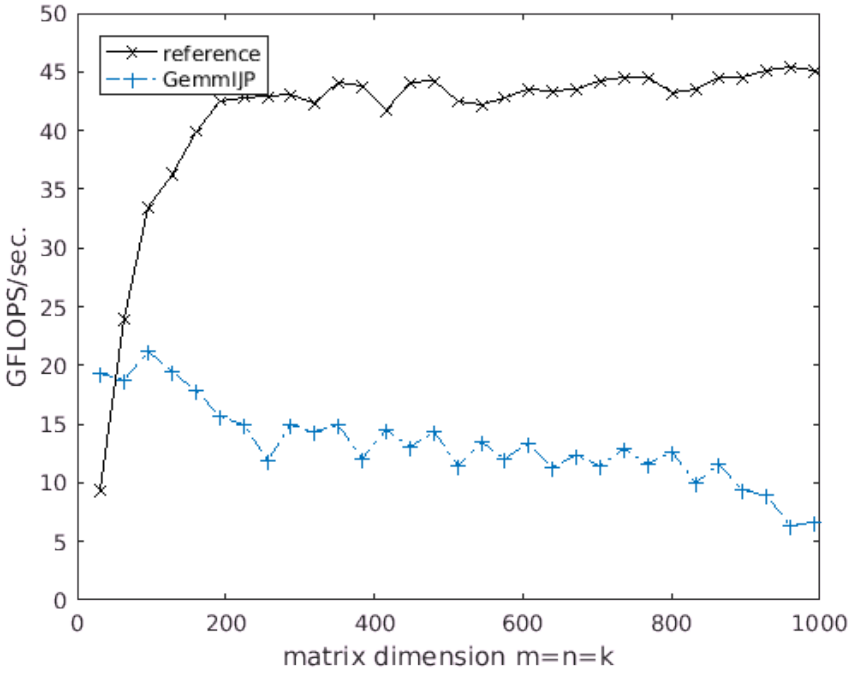
When all matrices are $n \times n$, we know that a matrix-matrix multiplication $AB + C$ requires $2n^3$ floating point operations (flops). This means that the number of operations performed per second is given by $2n^3/t$ flops, where t is the time, in seconds, for computing the multiplication. Now, a typical current core can perform billions of flops per second, so instead we report performance in GFLOPS/sec. (billions of flops per second): $2n^3/t \times 10^{-9}$.

```
ns = data_ref( :, 1 );                                      % Extract a vector of matrix size.
gflops = 2.0 * ns.^3 ./ data_ref( :, 2 ) * 1.0e-9;          % Compute a vector of corresponding
                                                            % GFLOPS/sec from the timing data.
plot( ns, gflops, 'k-x' );                                  % Plot the performance data

hold all
ns = data_GemmJI_Kernel_MRxNR( :, 1 );
gflops = 2.0 * ns.^3 ./ data_GemmJI_Kernel_MRxNR( :, 2 ) * 1.0e-9;
plot( ns, gflops, '-.+' );

xlabel( 'matrix dimension m=n=k' );
ylabel( 'GFLOPS/sec.' );
legend( 'reference', ...
        'GemmJI\_Kernel\_MRxNR', ...
        'Location', 'NorthWest' );
```

```
Warning: Ignoring extra legend entries.
```

```
% Adjust the x axis
v = axis;     % extract the current ranges
```

```
axis( [ 0 v(2) 0 v(4) ] )  % start the x axis and y axis at zero
```



Conclusion