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Parallel Processing – 10636523
SIMD Vectorization
Programming Assignment #2

In this assignment, related to SIMD vectorization using Intel SSE instructions for matrix-vector and matrix-matrix multiplication.The assignment involves using GCC, understanding SSE intrinsics, and implementing vectorized versions of these operations:

1- Vector-Vector Multiplication:
This mode compares the performance of scalar and vectorized implementations of vector-vector multiplication. The table presents the execution times for different input sizes (128, 256, 512).

2- Matrix-Vector Multiplication:
This mode compares the performance of scalar and vectorized implementations of matrix-vector multiplication. The table provides execution times for different input sizes (128, 256, 512).

3- Matrix-Matrix Multiplication:
This mode compares the performance of scalar and vectorized implementations of matrix-matrix multiplication. Execution times are reported for different input sizes (128, 256, 512).

Execution Times and Improvement Percentage:
The tables provide execution times for both scalar and vectorized versions of the operations. The improvement percentage is calculated as:
Improvement(%) = (Scalar/Vector)*100.
This percentage represents the speedup achieved by using SIMD vectorization.

We run code 12 times for every size, and exclude max and min values, then take average of 10 values to increase accuracy.

Results:

	Vector-Vector Multiplication		
Input-size	**Scalar**	**Vector**	**improvement(%)**
128	0.000003	0.000001	3
256	0.000004	0.000001	4
512	0.000006	0.000002	3
	Matrix-Vector Multiplication		
Input-size	**Scalar**	**Vector**	**improvement(%)**
128	0.0000706	0.0000623	1.133
256	0.0002714	0.0002635	1.03
512	0.0002805	0.0002644	1.06
	Matrix-Matrix Multiplication		
Input-size	**Scalar**	**Vector**	**improvement(%)**
128	0. 0110628	0. 003429	3.226
256	0. 0421675	0.0194112	2.172
512	0. 2899724	0. 1515174	1.913
Improvement(%) = Scalar/Vector			
When compiling use: gcc -O0			

Discussion:

1- Vector-Vector Multiplication:

For small input sizes (128, 256, 512), the vectorized implementation consistently outperforms the scalar implementation.

The speedup ranges from 3% to 4%, indicating that SIMD vectorization is beneficial for vector-vector multiplication, even for relatively small sizes.

2- Matrix-Vector Multiplication:

The vectorized implementation shows improvement over the scalar implementation for all input sizes (128, 256, 512).

The improvement percentage ranges from approximately 1.03% to 1.133%, demonstrating a moderate but consistent speedup in favor of SIMD vectorization.

3- Matrix-Matrix Multiplication:

Significant speedup is observed in the vectorized implementation across all input sizes (128, 256, 512).

The improvement percentage ranges from 1.913% to 3.226%, indicating a substantial performance gain when using SIMD vectorization for matrix-matrix multiplication.

Conclusion:

The results consistently show that SIMD vectorization, implemented using Intel SSE instructions, provides performance improvements for vector-vector, matrix-vector, and matrix-matrix multiplication.

The degree of improvement varies with the operation and input size, but in general, vectorization enhances the computational efficiency of these numerical algorithms.

It's important to note that the effectiveness of SIMD vectorization may depend on factors such as the specific hardware architecture and the characteristics of the algorithms being optimized.