Assignment 3: OMP

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Parallel Systems Programming

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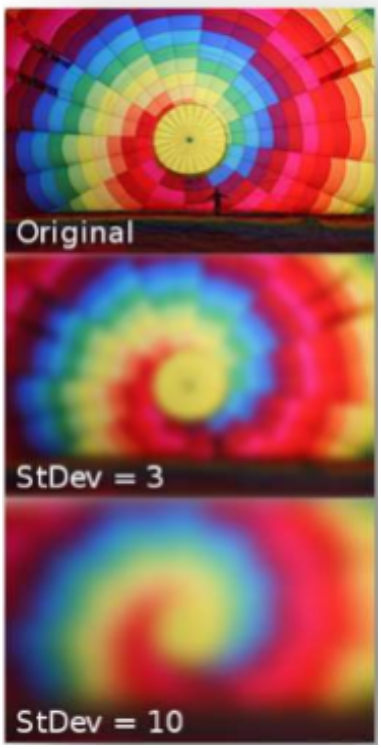
1 Gaussian blur algorithm

In this assignment, we will implement a blur algorithm. In particular, we will discuss the Gaussian Blur Algorithm.

Note that the algorithm is well-known and used in real-life; for example, Photoshop offers using Gaussian blur to "polish" photos:
https://www.adobe.com/creativecloud/photography/discover/gaussian-blur.html

In a nutshell, this algorithm blurs an image, using Gaussian function, in order to reduce image noise & details. In fact, the algorithm applies a "Gaussian kernel" to an image. We can control the intensity of the blur, for example:



Without going into too much detail, the algorithm averages the value of each pixel in relation to its neighbors.

You are given a sequential code in C, implementing the Gaussian Blur Algorithm; you are required to parallelize it using OpenMP!

1.1 Notes for parallelization

1. When thinking about how to parallelize the code, bear in mind that it requires thinking about shared resources; in particular, for example, pay attention to accessing the kernel, and maybe synchronization before changing certain pixels?

2. Parallelizing the algorithm doesn't just mean putting pragmas – think about the scheduling, shared resources, false sharing, synchronization, and about any other tools in OpenMP that we have learned in class.

2 Binary Search Tree synchronization

In this part you will implement a small library that provides the user with an integer binary-search tree data structure, with operations that can be used safely in parallel.

You are given the file `binary_tree.h`, and it is your job to implement the functions whose signatures appear in the file. You may choose your own implementation of the `TreeNode` structure, as long as the library functions behave as specified.

All operations always receive the *root* of the tree (i.e., the root of the original tree object) as their first argument. Functions that modify the tree (`insertNode` and `deleteNode`) must return the (possibly updated) root of the tree after the operation.

2.1 `binary_tree.h`

```
#ifndef BINARY_TREE_H
#define BINARY_TREE_H

#include <stdbool.h>

// Definition of a binary tree node
typedef struct TreeNode {
    int data;
    struct TreeNode *left;
    struct TreeNode *right;
} TreeNode;

// Function to create a new binary tree node.
// Returns a pointer to the newly allocated node.
TreeNode* createNode(int data);

// Function that insert a new value into the binary search tree.
// Returns a pointer to the new tree.
TreeNode* insertNode(TreeNode* root, int data);

// Function that delete a value from the binary search tree, if it exists.
// Returns a pointer to the new tree.
TreeNode* deleteNode(TreeNode* root, int data);

// Search for a value in the binary search tree.
// Returns true if 'data' is found, false otherwise.
bool searchNode(TreeNode* root, int data);
```

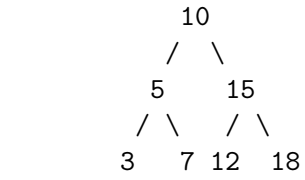
```
// Find the node with the minimum value in the tree.
// Returns a pointer to the node containing the smallest key, or NULL
// if the tree is empty.
TreeNode* findMin(TreeNode* root);

// The traversal functions below should PRINT the values of the nodes
// to stdout in the corresponding order. A simple and acceptable format
// is to print each value followed by a single space.

// Perform an in-order traversal and print all node values.
void inorderTraversal(TreeNode* root);

// Perform a pre-order traversal and print all node values.
void preorderTraversal(TreeNode* root);

// Perform a post-order traversal and print all node values.
void postorderTraversal(TreeNode* root);

For example, a simple implementation of inorderTraversal may use:
void inorderTraversal(TreeNode* root) {
    if (root == NULL) return;
    inorderTraversal(root->left);
    printf("%d ", root->data);
    inorderTraversal(root->right);
}


// Free all nodes in the binary tree.
// This function does NOT print anything.
void freeTree(TreeNode* root);

#endif // BINARY_TREE_H
```

2.2 Parallelism requirements

1. Those functions should not be parallel but should support parallelism aka – synchronized.
2. You need to assume different functions might be triggered on the same tree structures from different threads.
3. For example: `thread1` calls `insert` while `thread2` calls `delete`.
4. Don't just lock the entire functions as `critical`; think which functions depend on each other so that the data they return will be valid.
5. All of the work will be on **OMP**

2.3 Example

For example consider the binary tree:



The serial flow will return `true` for `findMin()->value == 2` if:

```
insert(2)
findMin()
// findMin()->value == 2 will return true
```

If thread1 will call `insert(2)` and then another thread will trigger `findMin()` the result should be the same (but not the other way around of course).

The same "edge cases" can happen with `insert` and `delete`.

3 Submission Guidelines

To reduce likelihood of misunderstandings, please follow these guidelines:

1. Work can either be done individually or in pairs.
2. Submission is through the submit.
3. Make sure that your solution compiles and runs without any errors and warnings on BIU servers.
4. In the first line of every file you submit, write in a comment your id and full name. For example: `/* 123456789 Israela Israeli */`.
5. Not using openMP in the task will result in an automatic 0, sequential code is unacceptable.

3.1 Environment & Submission

For this assignment, you must submit your code in a file named `ass3.zip`. This zip file should contain the files `binary_tree.h`, `binary_tree.c`, and the parallel version of the file provided for the Gaussian blur (without the `main` function), i.e., `guassonFilter.c`.

Note: Please submit the files with their exact names:

- `binary_tree.h`
- `binary_tree.c`
- `guassonFilter.c`

If you use different file names, you will receive an automatic grade of 0. If you choose to appeal this and send correct files, 10 points will automatically be deducted from your final score and you will start with 90.

3.2 Deadline: 25/12/2025