User manual

HoloStream (1.0)

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Introduction

This user manual is designed to guide users through the operation of HoloStream graphical user interface (GUI) developed for digital holographic microscopy (DHM) in an off-axis configuration with quasi-real time compensation.

This manual will guide you through the installation, configuration, and usage of the GUI, ensuring that you can efficiently operate the system for optimal results in your holographic microscopy experiments.

1. System Requirements

HoloStream is designed to operate efficiently on systems equipped with either a CPU or a GPU. Below are the detailed requirements based on the type of hardware setup:

CPU Requirements:

- **Operating System**: Windows 10 or Windows 11.
- **Camera Drivers**: Ensure that you have installed the appropriate drivers for the camera you will use with the system.
- **RAM**: A minimum of 8GB of RAM is required for basic functionality, but 16GB of RAM is recommended for optimal performance, especially for larger datasets or real-time processing.
- **Processor**: Any modern CPU that supports Windows 10/11.
- **Storage**: At least 10GB of free space for installation and operation, depending on the size of the data you will process.

GPU Requirements:

- **Operating System**: Windows 10 or Windows 11.
- **Camera Drivers**: Same as the CPU requirements, with proper drivers installed for the camera.
- **RAM**: 8GB minimum (16GB recommended for smoother GPU-based processing).

- **NVIDIA GPU**: An NVIDIA Graphics Unit Processor is required to leverage GPU acceleration.
- **CUDA Toolkit**: The GPU must support the CUDA toolkit, which is essential for parallel computing and optimizing holographic image processing. Ensure that you have installed the correct version of the CUDA toolkit for your GPU model (see appendix a) to know how to install it).
- **Storage**: At least 10GB of free space, similar to the CPU setup.

2. Installation and Setup

Installing the CPU Version of the GUI thought Executables files

The GUI for the CPU version running thought executable files is made for Windows systems. Follow the steps below to install and set up the GUI:

Download the Installation Files thought github:

- Download the HoloStream repository
- Uncompress it where you want to install it
- Go to Serial_version->Executables files
- Make a direct access to HoloStream.exe and put it on you desktop or where you want (You can skip this step but then you have to repeat this process every time you want to run the HoloStream app)

Folder Setup:

- The folder of executables files should have:
  - A folder called Imagenes with a subfolder called Temp
  - A folder called _internal
  - HoloStream.exe
  - HoloStream_tracking_interface.exe

- HoloStream_compensation_interface.exe
- parameters.txt

Camera Driver Installation:

- Ensure that you have the appropriate drivers for the camera you will be using installed on your system.
- Follow the camera manufacturer's installation instructions to complete this step if needed.

Running the Serial GUI:

- Double-click on Run the HoloStream.exe file to launch the GUI, if you don't have a camera, you can start the Tracking and compensation interface by a double click on HoloStream_tracking_interface.exe and HoloStream_compensation_interface.exe respectively.

Installing the CPU Version of the GUI thought Python files

The GUI for the CPU version running thought python can run on linux or windows systems. Follow the steps below to install and set up the GUI:

Download the Installation Files thought github:

- Download the HoloStream repository
- Uncompress it where you want to install it
- Go to Serial_version->Python_codes
- Download python 3.8 (later versions should also work, but HoloStream was tested on python 3.8) and make a virtual environment and install the requirements.txt.
- Run the HoloStream.py file.

Folder Setup:

- The folder of python_codes should have:
  - A folder called Imagenes with a subfolder called Temp

- The following python codes
    - Funciones.py
    - HoloStream.py
    - HoloStream_compensation_interface.py
    - HoloStream_tracking_interface.py
- icon.ico
- parameters.exe

Pre-steps for the installation of the GPU Version of HoloStream

Download Visual Studio C development for desktop components.

Download Cuda toolkit:

- Search for Cuda toolkit and choose the installation type of your preference.
- Test the installation opening a terminal and writing nvcc --version, this should show the version of Cuda installed, if it doesn't show anything, the installation went wrong or something is missing.

Installing the GPU Version of the GUI thought executable files

The GUI for the GPU version running thought executable files is made for Windows systems. Follow the steps below to install and set up the GUI:

Download the Installation Files thought github:

- Download the HoloStream repository
- Uncompress it where you want to install it
- Go to Parallel_version->Executables files
- Make a direct access to HoloStream.exe and put it on you desktop or where you want (You can skip this step but then you have to repeat this process every time you want to run the HoloStream app)

Folder Setup:

- The folder of executables files should have:
    - A folder called Imagenes with a subfolder called Temp
    - A folder called _internal
    - HoloStream.exe
    - HoloStream_tracking_interface.exe
    - HoloStream_compensation_interface.exe
    - Funciones.cu
    - parameters.txt

Camera Driver Installation:

- Ensure that you have the appropriate drivers for the camera you will be using installed on your system.
- Follow the camera manufacturer's installation instructions to complete this step if needed.

Running the Parallel GUI:

- Double-click on Run the HoloStream.exe file to launch the GUI, if you don't have a camera, you can start the Tracking and compensation interface by a double click on HoloStream_tracking_interface.exe and HoloStream_compensation_interface.exe respectively.

Installing the CPU Version of the GUI thought Python files

The GUI for the CPU version running thought python can run on linux or windows systems. Follow the steps below to install and set up the GUI:

Download the Installation Files thought github:

- Download the HoloStream repository
- Uncompress it where you want to install it

- Go to Serial_version->Python_codes
- Download python 3.8 (later versions should also work, but HoloStream was tested on python 3.8) and make a virtual environment and install the requirements.txt.
- The next steps need to change someparts of the skcuda library.
    - File cufft.py Line 16: You need to update this line to include Windows 11. Ensure that the number 11 is added to the array.
    - File cudart.py Line 12: Update the _win32_version_list variable to include the Windows 11 version. The modified line should look like this: _win32_version_list = [12, 101, 100, 92, 91, 90, 80, 75, 70, 65, 60, 55, 50, 40]. This ensures skcuda works correctly with newer Windows versions.
    - File cublas.py Line 27: Similarly to the previous file, update the _win32_version_list to include Windows 11: _win32_version_list = [12, 10, 100, 92, 91, 90, 80, 75, 70, 65, 60, 55, 50, 40].
    - File misc.py Line 241: Due to updates in Python, you need to replace np.float with just float to avoid deprecation warnings or errors:
    - File misc.py Line 637: Replace np.typeDict with np.sctypeDict due to changes in newer versions of NumPy
- Run the HoloStream.exe file.

Folder Setup:

- The folder of python_codes should have:
    - A folder called Imagenes with a subfolder called Temp
    - The following python codes
        - Funciones.py
        - HoloStream.py
        - HoloStream_compensation_interface.py
        - HoloStream_tracking_interface.py

- icon.ico
- Funciones.cu
- parameters.exe

3. GUI Overview

Upon starting the GUI, you will see that it is organized into six main sections, shown in figure 1, each designed to handle a specific aspect:

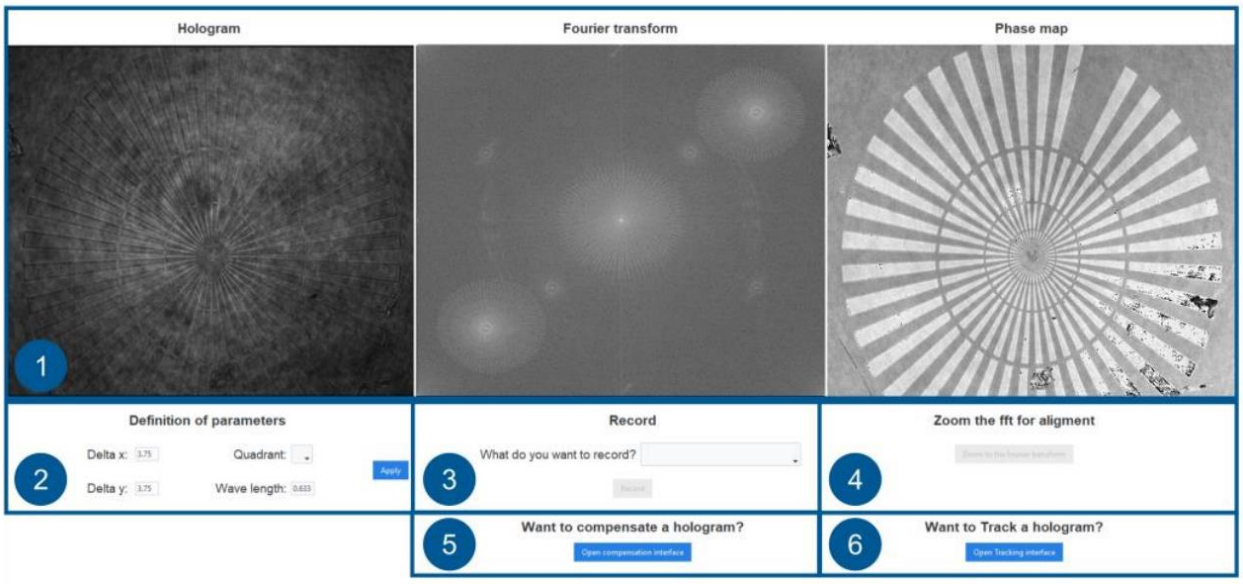

Figure 1. App name principal interface with sections enumerated

1. Hologram and Results Display:

In this section, the GUI will display the hologram captured by the system, the Fourier transform of the hologram, and the phase map compensated through the SHPC (Self-Healing Phase Compensation) algorithm. These visualizations will appear once the user starts the capture process.

2. SHPC Parameters:

This section is for introducing the parameters used by the SHPC algorithm. The GUI comes with some pre-selected default values that the user can modify be adjusted by editing a text file that stores the values.

3. Recording Options:

In this section, you can choose to record either the hologram and the phase map together or only the phase map. This allows for flexibility depending on the type of data you wish to save.

4. System Alignment:

This section is specifically designed to help with system alignment. It displays the Fourier transform of the recorded hologram and includes a zoom option that allows the user to focus on the order maximum in more detail, aiding in precise alignment of the optical system.

Compensation of pre-recorded holograms GUI:

This section provides access to the separate hologram compensation GUI. By selecting this option, the user can switch to the compensation interface for prerecorded holograms.

This interface is divided into three sections as shown in figure 2. This section provides an overview of the sections and their functions.

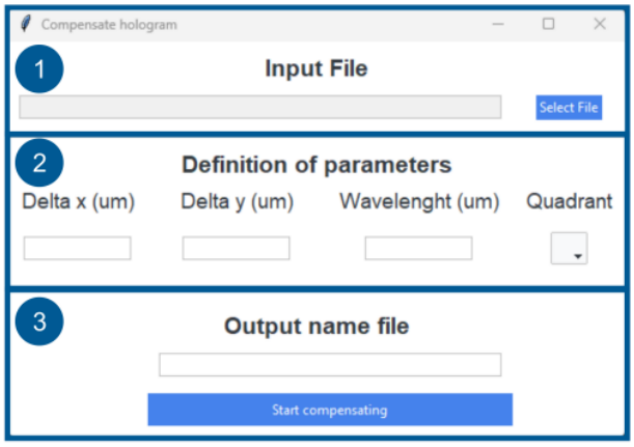

Figure 2. Compensation of pre-recorded holograms interface with sections enumerated

Section 1: Upload Input File

In this section, you can upload the input file containing the hologram data. The input file is expected to be in a valid video format, and you can browse to the location of the file on your computer or enter the file path manually. Once the file is uploaded, you can proceed to the next section.

Section 2: Define Parameters

In this section, you need to define the parameters required for the quasi-real-time digital holographic microscopy process. These parameters include:

- Pixel size of the camera for the x-axis and y-axis: These values are critical in determining the spatial resolution of the reconstructed image. Enter the pixel size values in units of [units, e.g., micrometers, pixels, etc.].
- Quadrant where the order +1 is: This parameter determines the orientation of the hologram data. Select the quadrant where the order +1 is located from the dropdown menu.
- Wavelength: Enter the wavelength of the laser used in the holographic microscopy process in units of [units, e.g., nanometers, micrometers, etc.].

Section 3: Select Output File Name

In this section, you can select the output file and start the compensation process by clicking on the "Start Compensation" button. The compensation process will take some time depending on the size of the input file and the computational resources available. Additionally, once the hologram is compensated, a message box will appear, and the resulting video will be on the carpet where the files are.

Tracking interface:

This section provides access to the separate tracking GUI, that consists of four key parts, shown in figure 3, that allow users to load a hologram video, set parameters, and track objects based on selected areas.

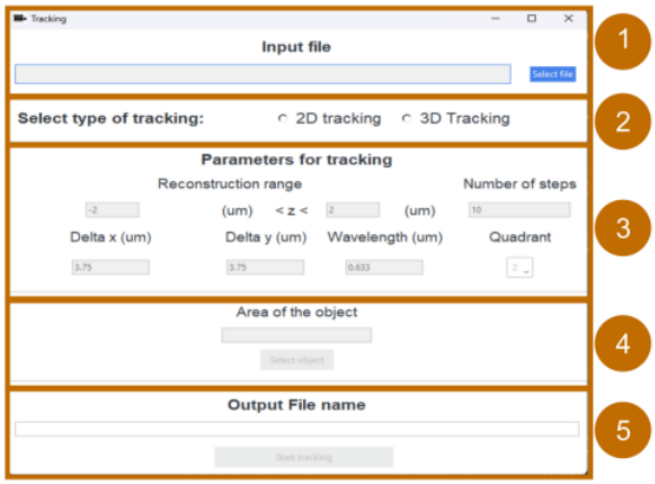

Figure 3. Tracking interface with sections enumerated

Section 1. Input File:

This is where the user selects the hologram video file they want to track. By clicking "Select file," the user can browse and choose a video.

Section 2. Select Type of Tracking:

The user can choose between 2D or 3D tracking modes depending on their analysis needs.

Section 3. Parameters for Tracking:

This section is only enabled if the user wants to make a 3D tracking and contains the essential parameters for tracking and:

- **Reconstruction Range (z)**: Define the minimum and maximum values for the z-axis in micrometers.
- **Delta x** and **Delta y**: Specify the pixel resolution or spatial sampling along the x and y directions in micrometers.
- **Wavelength**: Set the wavelength of the laser used for holography in micrometers.
- **Quadrant**: Choose the quadrant in the Fourier domain that will be used for analysis.

Section 4. Area of the Object:

The user can select the area of the object they want to track. After selecting a valid video, they can use the "Select object" button to manually define the area.

Section 5. Output File Name:
The user specifies the name for the output file, which will store the tracked video data. Once all fields are filled, the "Start tracking" button becomes active to initiate the tracking process.

4. Step-by-Step Workflow

This section provides a step-by-step guide to capturing holograms, aligning the optical system, recording data, and tracking objects.

Step 1: Start the Application

- Ensure your camera is properly connected to the computer before starting the GUI.
- Launch the application by double-clicking on interfaz_solo_serial.exe.

Step 2: Define SHPC Parameters

- Go to **Section 3** of the main interface where you will define the parameters for the SHPC (Semi Heuristic Phase Compensation) algorithm.
- Click "Apply" to begin capturing holograms using these parameters.
- If there is a wrong value for any field, change it to the appropriate value and then click “Apply” again.

Step 3: Align the Optical System

- If the optical system is already aligned, proceed to **Section 4** to record the hologram and phase map, or just the phase map.
- After starting the capture, go to **Section 5** to align the optical system if needed. The Fourier transform of the captured hologram will be displayed, and you can use the zoom option to focus on the maximum of the order, and then, adjust the optical system as necessary to ensure proper alignment.

Step 4: Save the Recording

- Select the option save hologram or save hologram and reconstruction and then the button records to start recording, then the next time you press the same button the frames

recorded will be saved, the name should be origen_{timestamp} for the hologram and reconstruccion_{timestamp} for the phase map.

5. Performance Considerations

The performance of the GUI, particularly the speed at which frames are compensated, depends on the hardware of the system being used. Here are some general guidelines based on system specifications:

CPU Principal GUI:

- The CPU version of the GUI can compensate approximately between **4 to 5 frames per second** when running on an Intel Core i5 10th generation processor with 16GB of RAM.
- The actual performance may vary depending on your specific hardware configuration, the number of subprocesses running on your computer, and other system loads.

GPU Principal GUI:

- The GPU version of the GUI, when paired with an Intel Core i5 10th generation processor, 16GB of RAM, and an NVIDIA RTX2060 GPU, can compensate for **around 14 to 16 frames per second**.
- Similar to the CPU version, performance may fluctuate based on your system's specifications and background processes.

6. Troubleshooting

This section addresses common issues users may encounter while using the GUI and offers solutions or workarounds.

Error: Unable to Execute Select Area Twice in the Tracking GUI

- **Issue**: There is a known bug where attempting to select the area twice in the tracking GUI causes an error that will stop the tracking GUI.
- **Solution**: If this error occurs, reopen the GUI. We are working on a fix, and it will be available in a future patch.

Error: Incorrect Parameter Inputs

- **Issue**: The GUI may generate errors if the input parameters are incorrect, leading to misconfigurations.
- **Solution**: Double-check that the parameters you enter are appropriate for your current optical setup or the video you wish to track. Using correct parameters ensures smoother operation and reduces the chance of errors.

Error: CUDA is installed but not recognized

- **Issue**: If you install CUDA toolkit but
- **Solution**: Double-check that the parameters you enter are appropriate for your current optical setup or the video you wish to track. Using correct parameters ensures smoother operation and reduces the chance of errors.

7. Technical Support

For technical assistance or to report issues with the GUI, follow these guidelines:

- **Contact Email**: jdmoralesb@eafit.edu.co
- **Subject Line for Issue Reports**: When reporting bugs or requesting new features, use the subject line: "Issue report name GUI".

In the body of your email, please provide a detailed description of the issue you encountered, along with any relevant screenshots or error messages. This will help the support team address your issue more efficiently.