**Automated Microscope-Based Graphene Scanning and Classification through External Mechanism**

Objective:

The objective of this project is to increase the efficiency of graphene identification using optical microscopy. This will be achieved by employing AI-based computer vision techniques for analyzing images obtained from a microscope. Coupled with this, an externally attached mechanism will be used to control the microscope for scanning graphene on a SiO2 wafer. The system will automatically capture images of different visually discernible color regions and store them in corresponding folders. Importantly, the applicability of this project is not limited to physics laboratories. As the mechanical control is primarily dependent on the AI model, this system can be utilized in medical, biological, and chemical fields. Any task that requires extensive scanning or operation via a microscope can be automated by attaching a motor to the existing microscope, thereby enabling automated searching without the need for replacing the current microscope.

Components:

1. Microscope: An optical microscope will be the primary instrument used for capturing images of graphene on a SiO2 wafer. It is crucial that the image captured by microscope can be accessed by computer lively.
2. Computer Vision Software: AI-based computer vision techniques will be used to analyze the captured images. For now it is of utmost importance that the microscope is capable of providing live image feeds which can be accessed and analyzed directly on a computer. However, in the future development, for microscopes that are not initially capable of providing live image feeds to a computer, we plan to add components for image capturing and processing to enhance their functionality.

* For the computer vision software aspect of the project, our initial approach is to train a U-Net model. This model forms the backbone of our image analysis system, offering a ready-to-use solution for identifying graphene layers in the images captured by the microscope.

By developing our own model, we have the flexibility to fine-tune it according to the specific needs of our project. The present focus is on training a model that can distinguish various layers of graphene as seen under different microscopes. Given the variability in images captured by distinct microscopes, it's crucial to normalize these images and minimize the training dataset's size.

Following this initial automated categorization, manual labeling could be performed to further refine the accuracy of the model. This iterative process of machine clustering and human annotation could potentially result in a versatile and efficient system for image-based material identification and categorization.

Note that Axial DeepLab is a novel transformer model for computer vision segmentation for medical image. It would be beneficial to try applying this model to 2D Material segmentation.

While this approach should provide a robust foundation for our project, it's important to note that machine learning models might require regular updates and retraining to maintain accuracy over time, particularly as new data and use cases are encountered. Thus, ongoing maintenance and performance monitoring will be an essential aspect of our software development lifecycle.

1. Mechanical Structure: A structure will be externally attached to the microscope to automate the scanning process. This motor will be controlled using the computer vision software.

* Motor: Both inner and outer hollow cylinder will be controlled by Direct Current (DC) motor as the driving source. DC motors are ideal because they can reverse direction by simply reversing the polarity of the input current. Each motor can be controlled independently via a switch or a more sophisticated electronic controller.
* Large Hollow Cylinder: The larger hollow cylinder will have an in-built gear on the inside that will mesh with a gear connected to its corresponding motor. As the motor rotates, the rotation of the gear will be directly transferred to the large sleeve, causing it to rotate. By changing the polarity of the input current to the motor, the large hollow cylinder can rotate in both clockwise and counterclockwise directions.
* Small Hollow Cylinder: The small sleeve will be designed to rotate freely within the large hollow cylinder and will also have an in-built gear. This gear will mesh with a gear connected to the small hollow cylinder's corresponding motor. Like the large hollow cylinder, the small hollow cylinder can achieve clockwise and counterclockwise rotation by changing the polarity of the input current to the motor.
* Bearing System: To ensure the free rotation of the small sleeve within the large one, bearings can be positioned between the sleeves. Bearings can reduce friction during rotation and help maintain good alignment between the hollow cylinder.

1. 3D printing holder: A holder used to physically manage the control system including motor and circuit boards.
2. embedded system: The embedded system provides the necessary hardware interface for our project, establishing the connection between the control signals from the computer software and the motor. Below are some of the electronic boards and components that might be used:
   * Microcontrollers: These are used to control the motors and receive signals from the computer software. Examples include Arduino Uno or Raspberry Pi.
   * Stepper Motors: These physically turn the knobs of the microscope. The specific model should be chosen based on the size of the knob and the required torque for turning.
   * Motor Drivers: This is a circuit board used to control the direction, speed, and position of the motor. For example, an A4988 stepper motor driver could be used to drive stepper motors.
   * Rotary Encoders: These can be used to detect the actual position of the microscope knobs, ensuring precise control.
   * Power Supply: This provides power to the entire system. It must meet the voltage and current requirements of the motor and microcontroller.
   * Communication Interface: Such as a USB interface, for connecting the microcontroller and the computer.

When designing the embedded system, details such as protective circuits, interface layout, and casing must also be considered. In addition, some expansion modules like Wi-Fi modules could make the system support remote control, improving its convenience and flexibility.

1. Storage System: A well-structured storage system will be in place to categorize and store the captured images in different folders based on their visual properties.

Engineering Approach:

Understand and Define Requirements: We will begin by defining the system requirements clearly. This includes understanding the limitations and capabilities of the microscope and the motor, the type of images to be captured, the details to be identified using computer vision, and the method of categorizing and storing images.

Design System: Based on the defined requirements, we will design the complete system. This includes designing the software algorithms for image analysis, motor control, and the image storage system.

Development and Integration: The next step involves developing the system components and integrating them to form a complete working system. This includes programming the motor control and image analysis software, and setting up the image storage system.

Testing and Validation: Once the system is ready, it will undergo rigorous testing to ensure that it meets all defined requirements. Any identified issues will be fixed, and the system will be validated for its performance and efficiency.

Deployment: Once validated, the system will be ready for deployment. The system will be installed and integrated with the microscope in the laboratory, and user training will be provided if necessary.

Maintenance: Regular system maintenance will be conducted to ensure optimal system performance and to accommodate any changes in requirements or conditions.