Design considerations for automated microscope control

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***For a range of applications, from blood analysers through to semiconductor capital equipment, automated microscopes achieve image gathering that is both faster and significantly more accurate.* To optimise the clarity and detail of image capture, an automated microscope's motion control architecture must synchronise an XYZ axis system with optimum precision.**

Gerard Bush, engineer at motion control specialist INMOCO, explains the key considerations in automated microscopy motion design.

Vital to applications in life sciences and across industry, automated microscopy demands a high level of motion control precision to optimise the observation of samples. Operating on the same principle as a three-axis gantry over X, Y, and Z axes, positioning accuracy is measured in microns or even nanometres.

The X and Y axes control the movement of the optical system to view specific regions of the sample, and a relatively small error in positioning can lead to imaging artifacts or missed regions in a scan. The Z-axis, responsible for focusing the image, doesn't demand the same exacting level of precision due to the microscope system's depth of field and range of positions where the image remains in focus, yet the need for resolution remains important.

To achieve this level of precision, premium grade automated microscopes typically integrate linear direct drive brushless DC motors. While the control electronics of a brushless DC set-up optimises precision, a direct drive coupling minimises the challenges of backlash, friction, and mechanical compliance that can disturb smooth and controlled motion. Piezo motors, which expand or contract when electrically stimulated to generate motion, can also be integrated to achieve high levels of precision and virtually silent operation. For more cost-effective designs, rotary brushless DC motors with a ball screw are an alternative, or even stepper motors.

Precise position feedback

To drive the motor, ultra high-resolution encoders have helped to improve the performance of automated microscopes. Absolute position encoders are preferred for higher precision and can provide multi-turn feedback, recording both the angular position within a turn and the total number of turns. Incremental position encoders, which provide relative position tracking, are also an option where designs have higher cost demands.

Digital serial connection schemes like SSI, BiSS-C, and EnDat, which are protocols for transferring position data from an encoder to a controller, have further helped optimise precision thanks to advantages such as synchronised or bidirectional communication and cyclic data exchange. Alternatively, sin/cos encoders, based on analogue signals that can transfer back to digital, achieve high resolution feedback with smooth signals less affected by electrical noise.

Motion control requirements

To reach the precision require to coordinate the XY table of the microscope, high performance, low noise current loops, controlling the torque output of the motors, must be combined with a high-speed servo loop. Responsible for precision positioning, a servo loop speed of at least 10 kHz is recommended as even the lowest error in current control can cause positioning disturbances. The controller should also be located as close to the motor as possible to minimise noise in the current sensing circuitry.

In terms of trajectory, automated microscopy motion profiles typically include point-to-point XY moves and constant velocity pattern scans with simultaneous image capture by camera. To synchronise stage movement and image capture, hardware-based position capture uses a compare register to signal an image capture when an exact encoder position is achieved. Systems can specify a single capture at one location or a selection of potentially thousands of capture trigger points.

Integrating the synchronisation of focus, coordinating the X and Y axes with the commanded position of the Z axis maximises accuracy over the sample movement area. 3D ‘maps’ that chart the effective focal height of the XY plane can pre-compensate the Z axis position command to resolve deviation or drift in sample form.

Specifying motion control

Integrated chip-based embedded motion control, provided by specialists such as Performance Motion Devices, is recommended to achieve the desired design characteristics that optimise the precision required for automated microscopy applications. PMD’s Magellan IC motion controllers can be combined with PMD ION compact drives, while the PMD Prodigy Motion Control Board offers a complete control package.

At INMOCO, our engineers can help specify a complete motion control architecture, including PMD control electronics, as well linear direct drive brushless DC motors, and encoders. Partnering with scientific and lab equipment for sectors including life sciences, as well as wider industry, our engineers are well versed in meeting the needs of design engineers who rely on precision motion control technology.

Image Captions:

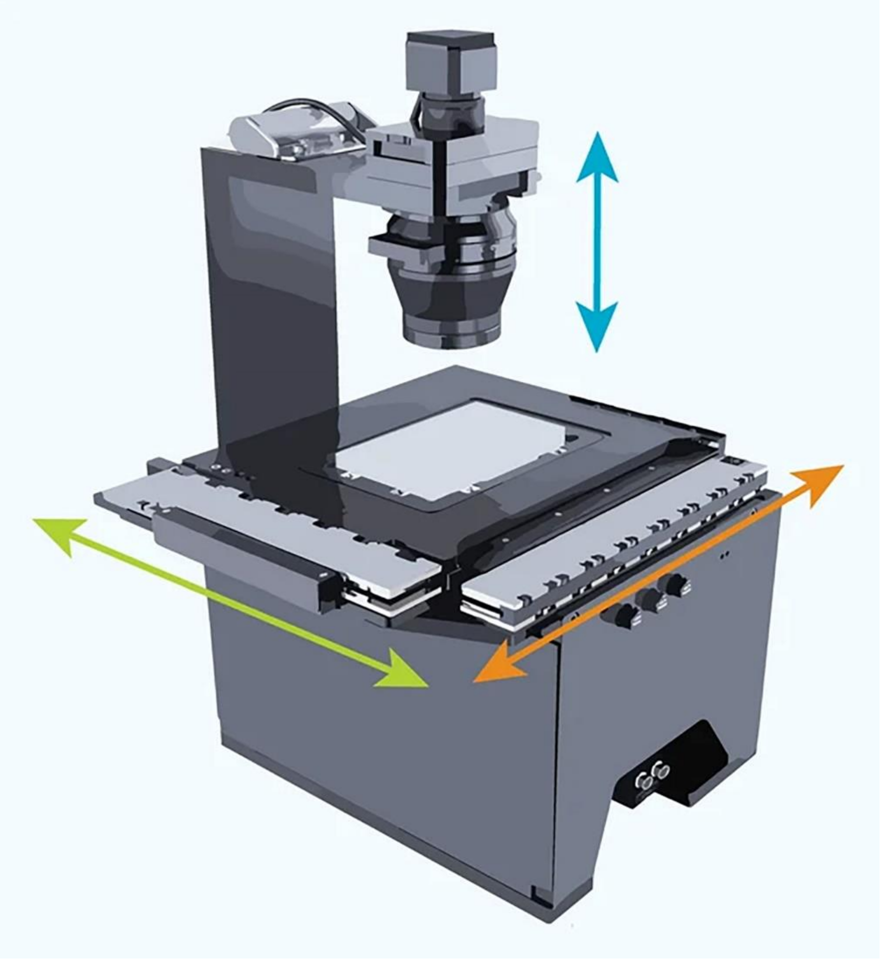

Image 1: Automated microscopes are a vital part of a broad array of equipment.

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About INMOCO

Established in 1987, INMOCO now offers an extensive range of motion control equipment including: compact servo amplifiers, position controllers, stepper motors, PLC controllers, linear motors, sensors, electric actuators and gearheads. INMOCO's product portfolio is supported by extensive applications and technical expertise, in addition to customer-specified electro-mechanical development and sub- assembly services; including calibrating and testing in a class 10,000 clean room facility.

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