Observer Development for Automatic STEM Closed-Loop Control

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Summary

Next-generation STEMs will include high-throughput, autonomous, nano-measuring capabilities. Consequently, their design will require to take into account their time-dependent responses and dynamics. In this work, control theory is proposed as the theoretical (and practical) framework necessary to tackle such design. The approach is illustrated via a defocus control example, which includes a new control-oriented model STEM.

I. A new way of thinking about STEMs

- STEMs can be considered systems that map inputs into outputs.

- To ensure high-throughput and autonomy:
  - The map (i.e., the relationship) between inputs and outputs cannot be assumed constant.
  - The time required to exert changes must be taken into account.

II. Defocus control (not autofocus)

- Defocus control requires a model of the objective lens and a defocus sensor.

- Defocus control makes use of the feedback concept.
  - A reference value is compared to a measurement.
  - Based on their difference, the controller changes the objective lens current.
  - These actions are repeated periodically.

III. Defocus sensor

- An image-based defocus sensor was developed:
  - It works on diffractograms of amorphous materials.
  - It requires knowledge of the defocus range under consideration.
  - It does not require user intervention.