Test Plan:
STEM Moiré GPA

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1 Revision History

Date	Version	Notes
Date 1	1.0	Notes

2 Symbols, Abbreviations and Acronyms

symbol	**description**
T	Test

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3 General Information

3.1 Purpose

The purpose of the document is to provide the plan for testing STEM Moiré GPA software.

3.2 Scope

3.3 Overview of Document

4 Plan

4.1 Software Description

STEM Moiré GPA software is converting STEM Moiré hologram into deformation maps. Details on the goal and the requirements of STEM Moiré GPA are provided in the Problem Statement and the SRS documents. Acronyms, symbols and terminologies used in the following document are the same as the ones in the SRS document.

4.2 Test Team

The author is the only member of the test team.

4.3 Automated Testing Approach

blbabla

4.4 Verification Tools

4.5 Non-Testing Based Verification

5 System Test Description

5.1 Tests for Functional Requirements

5.1.1 Output error characterization

Test R 3 in IM 1: Correctness of the sampling theory application when undersampling g

Test 1 Test-aliasing-frequency-simple

- ⋆ Type: Functional, Dynamical
- ⋆ Initial State:
- ⋆ Input: $I_{C_{\text{ref}}} = e^{2i\pi gx}$, p such that $\overrightarrow{q} = \frac{1}{p}\vec{u_x}$
- ⋆ Expected output : $\widetilde{I}_{SHM_{\text{sim}}} = \delta(\vec{\nu} - \vec{q})$
- ⋆ Output: $\widetilde{I}^{t}_{SHM_{\text{sim}}}$ to be tested as a Dirac delta function at $\overrightarrow{q}$

The position in frequency space of the aliased frequency (transformation of one g from Ic to one g of IM) is key to identify the vector $\overrightarrow{q_{n,m}}$. Test 1 is designed to check if the most basic transformation when under sampling is correctly performed. More complex versions of Test 1 can be designed with reference functions having, for example, a continuous description in Fourier space. Nevertheless, the more complex tests will cover way more cases than what $I_{C_{\text{ref}}}$ typically is (a sparse function). Depending on the time availability, a more complete version of Test 1 will be designed.

Test R 7 in IM 2: Correctness of the GPA method application

Test 2 Test-Phase-Extraction-No-Strain

- ⋆ Type: Functional, Dynamical
- ⋆ Initial State: ?

- ⋆ Input: $I_{SMH_{exp}} = e^{2i\pi gx}$, Mask M of one pixel at $g\overrightarrow{u_x}$ in $\widetilde{I}_{SMH_{exp}}$
- ⋆ Expected output $P_{\Delta\overrightarrow{g_j}^{M_{exp}}} = 0$, $\Delta\overrightarrow{g_j}^{M_{exp}} = \overrightarrow{0}$,
- ⋆ Test output:$P_{\Delta\overrightarrow{g_j}^{M_{exp}}}{}^t$, $\Delta\overrightarrow{g_j}^{M_{exp}\,t}$
  - $\forall \vec{r} \in \mathbb{I},\ E_{P_{\Delta\overrightarrow{g_j}^{M_{exp}}}}(\vec{r}) = |P_{\Delta\overrightarrow{g_j}^{M_{exp}}}{}^t(\vec{r})|$
  - $\forall \vec{r} \in \mathbb{I},\ E_{\Delta\overrightarrow{g_j}^{M_{exp}}}(\vec{r}) = |\Delta\overrightarrow{g_j}^{M_{exp}\,t}(\vec{r})|$

Test 3 Test-Phase-Extraction-Known-Strain

- ⋆ Type: Functional, Dynamical
- ⋆ Initial State:
- ⋆ Input: $I_{SMH_{exp}} = e^{2i\pi(g+K(x))x}$, Mask M centred on $g\overrightarrow{u_x}$ in $\widetilde{I}_{SMH_{exp}}$ and with the minimum radius to include $K(x)$.
- ⋆ Expected output $P_{\Delta\overrightarrow{g_j}^{M_{exp}}} = K(x)x$, $\Delta\overrightarrow{g_j}^{M_{exp}} = K(x)\overrightarrow{u_x}$,
- ⋆ Test output:$P_{\Delta\overrightarrow{g_j}^{M_{exp}}}{}^t$, $\Delta\overrightarrow{g_j}^{M_{exp}\,t}$
  - $\forall \vec{r} \in \mathbb{I},\ E_{P_{\Delta\overrightarrow{g_j}^{M_{exp}}}}(\vec{r}) = |P_{\Delta\overrightarrow{g_j}^{M_{exp}}}{}^t(\vec{r}) - P_{\Delta\overrightarrow{g_j}^{M_{exp}}}(\vec{r})|$
  - $\forall \vec{r} \in \mathbb{I},\ E_{\Delta\overrightarrow{g_j}^{M_{exp}}}(\vec{r}) = |\Delta\overrightarrow{g_j}^{M_{exp}\,t}(\vec{r}) - \Delta\overrightarrow{g_j}^{M_{exp}}(\vec{r})|$

Test 4 Test-Phase-Extraction-Mask

- ⋆ Type: Functional, Dynamical
- ⋆ Initial State:
- ⋆ Input: $I_{SMH_{exp}} = e^{2i\pi(g+K(x))x}$, Mask M centred on $g\overrightarrow{u_x}$ in $\widetilde{I}_{SMH_{exp}}$ with different radius ϵ.
- ⋆ Expected output $P_{\Delta\overrightarrow{g_j}^{M_{exp}}} = K(x)x$, $\Delta\overrightarrow{g_j}^{M_{exp}} = K(x)\overrightarrow{u_x}$,
- ⋆ Test output:$P_{\Delta\overrightarrow{g_j}^{M_{exp}}}{}^t$, $\Delta\overrightarrow{g_j}^{M_{exp}\,t}$
  - $\forall \vec{r} \in \mathbb{I},\ E_{P_{\Delta\overrightarrow{g_j}^{M_{exp}}}}(\vec{r}, \epsilon) = |P_{\Delta\overrightarrow{g_j}^{M_{exp}}}{}^t(\vec{r}, \epsilon) - P_{\Delta\overrightarrow{g_j}^{M_{exp}}}(\vec{r})|$

- $\forall \vec{r} \in \mathbb{I},\ E_{\Delta \overrightarrow{g_j}^{M_{exp}}}(\vec{r}, \epsilon) = |\Delta \overrightarrow{g_j}^{M_{exp}\,t}(\vec{r}, \epsilon) - \Delta \overrightarrow{g_j}^{M_{exp}}(\vec{r})|$

Because the GPA method is itself based on an approximation (see IM 2 in SRS document), errors from the algorithm are added to the errors from the code. Both are probed at the same time in the tests and cannot be fully separated. Test 2 is probing the accuracy and the precision in the most basic case possible (no strain) and is a first indicator of the IM 2 performance. Test 3 and Test 4 are closer to a real case scenario and highlight a more realistic version of IM 2 performance. To get quantitative trends, the error will be characterized as a function of the mask properties (such as the radius) and the deformation magnitude. This characterization will allow the GPA algorithm of STEM Moiré GPA to be compared with other software using the same GPA algorithm. Another interest of the performance characterization is to see a quantitative effect of the user inputs on IM 2 and provide a "good practice guidance" in the user manual.

Test R 10 in IM 3: Correctness of the unstrained reference calculation

Test 5 Test-constant-delta-g

- ⋆ Type: Functional, Dynamical
- ⋆ Initial State:
- ⋆ Input:
  - $\forall \vec{r} \in \mathbb{I},\ \Delta \overrightarrow{g}^{M_{\text{exp}}}(\vec{r}) = \overrightarrow{C}$
  - U array of 1 pixel wherever on $\Delta \overrightarrow{g}^{M_{\text{exp}}}(\vec{r})$
  - $\overrightarrow{g}^{M_{\text{exp}}} = g_x{}^{M_{\text{exp}}}\overrightarrow{u_x} + g_y{}^{M_{\text{exp}}}\overrightarrow{u_y}$
- ⋆ Expected output: $\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}} = \overrightarrow{g}^{M_{\text{exp}}} - \overrightarrow{C},\ \Delta \overrightarrow{g_j}_{\text{cor}}^{M_{\text{exp}}} = \overrightarrow{0}$
- ⋆ Output: $\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}\,t}$, $\Delta \overrightarrow{g_j}_{\text{cor}}^{M_{\text{exp}}\,t}$
  - $E_{\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}}} = ||\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}\,t} - \overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}}||$
  - $\forall \vec{r} \in \mathbb{I},\ E_{\Delta \overrightarrow{g_j}_{\text{cor}}^{M_{\text{exp}}}} = ||\Delta \overrightarrow{g_j}_{\text{cor}}^{M_{\text{exp}}\,t}||$

Test 5 is not realistic but test the code directly. Increasing the size of U, should have absolutely no effect on the output.

Test 6 Test-constant-delta-g-with-noise

- Type: Functional, Dynamical
- Initial State:
- Input:
  - $\overrightarrow{N}$, 2D random noise
  - $\forall \vec{r} \in \mathbb{I},\ \Delta \overrightarrow{g}^{M_{\text{exp}}}(\vec{r}) = \overrightarrow{C} + \overrightarrow{N}$
  - U array of $n \times m$ pixels wherever on $\Delta \overrightarrow{g}^{M_{\text{exp}}}(\vec{r})$
  - $\overrightarrow{g}^{M_{\text{exp}}} = {g_x}^{M_{\text{exp}}} \overrightarrow{u_x} + {g_y}^{M_{\text{exp}}} \overrightarrow{u_y}$
- Expected output: $\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}} = \overrightarrow{g}^{M_{\text{exp}}} - \overrightarrow{C},\ \Delta \overrightarrow{g_j}_{\text{cor}}^{M_{\text{exp}}} = \overrightarrow{0}$
- Output: $\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}\,t}, \Delta \overrightarrow{g_j}_{\text{cor}}^{M_{\text{exp}}\,t}$
  - $E_{\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}}} = ||\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}\,t} - \overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}}||$
  - $\forall \vec{r} \in \mathbb{I},\ E_{\Delta \overrightarrow{g_j}_{\text{cor}}^{M_{\text{exp}}}} = ||\Delta \overrightarrow{g_j}_{\text{cor}}^{M_{\text{exp}}\,t}||$

Test 6 is more representative of a real case than Test 5 and will be use to characterize the evolution of the error with respect to the level of noise and the size of U. The evaluation of $\overrightarrow{g}_{\text{uns}}^{M_{\text{exp}}}$ is critical on the quantitative estimation of strain and rotation.

Test 7 Test-varying-delta-g

- Type: Functional, Dynamical
- Initial State:
- Input:
  - $\forall \vec{r} \in \mathbb{I},\ \overrightarrow{g}^{M_{\text{exp}}}(\vec{r}) = \overrightarrow{C}(\vec{r})$
  - U array of $n \times m$ pixels wherever on $\Delta \overrightarrow{g}^{M_{\text{exp}}}(\vec{r})$

- $\overrightarrow{g}^{M_{\exp}} = g_x{}^{M_{\exp}}\overrightarrow{u_x} + g_y{}^{M_{\exp}}\overrightarrow{u_y}$

* Expected output: $\overrightarrow{g}^{M_{\exp}}_{\text{uns}} = \overrightarrow{g}^{M_{\exp}} - F(\overrightarrow{C}(\vec{r}))$, $\Delta\overrightarrow{g_j}^{M_{\exp}}_{\text{cor}} = \overrightarrow{C}(\vec{r}) - F(\overrightarrow{C}(\vec{r}))$ where $F(\overrightarrow{C}(\vec{r}))$ is the best possible linear fit of $\overrightarrow{C}(\vec{r})$ in U.

* Output: $\overrightarrow{g}^{M_{\exp}\,t}_{\text{uns}}, \Delta\overrightarrow{g_j}^{M_{\exp}\,t}_{\text{cor}}$

  - $E_{\overrightarrow{g}^{M_{\exp}}_{\text{uns}}} = ||\overrightarrow{g}^{M_{\exp}\,t}_{\text{uns}} - \overrightarrow{g}^{M_{\exp}}_{\text{uns}}||$
  - $\forall \vec{r} \in \mathbb{I},\ E_{\Delta\overrightarrow{g_j}^{M_{\exp}}_{\text{cor}}} = ||\Delta\overrightarrow{g_j}^{M_{\exp}\,t}_{\text{cor}} - \Delta\overrightarrow{g_j}^{M_{\exp}}_{\text{cor}}||$

Test 7 might be impossible to properly interpret but the idea is to see the effect an improper choice of an unstrained reference. If a non uniform deformation field is present in the reference, STEM Moiré GPA is trying to find the best linear fit to cancel it out. A solution is proposed whatever the precision of the fit. However, if the quality of the fit is poor, it could be possible that STEM Moiré GPA informs/warns the user of a potential problem in the reference chosen.

5.2 Tests for Nonfunctional Requirements

5.2.1 Evolution of precision with noise in STEM Moiré GPA

Test NR 8 and NR 9

Test 8 Test-Black-Box-STEM-Moiré-GPA

* Type: Functional, Dynimical, Black box

* Initial State: All user inputs are predefined $(p, M_1, M_2, U, \overrightarrow{q_{n_1,m_1}}, \overrightarrow{q_{n_2,m_2}})$ except the STEM Moiré hologram

* Input: STEM Moiré holograms with different level of noise (from no noise to high level of noise):

  - $I_{SMH_{\exp}} = I(\vec{r}) + N(\vec{r})$ with I a perfect SMH (with a defined strain field $\varepsilon(\vec{r})$ and rotation field $\omega(\vec{r})$) and N a random noise

* Expected output $\forall \vec{r} \in \mathbb{I},\ \varepsilon(\vec{r})^t = \varepsilon(\vec{r}) \wedge \omega(\vec{r})^t = \omega(\vec{r})$

* Output:

– $\forall \vec{r} \in \mathbb{I},\ E_{\varepsilon}^{\text{STEM Moiré GPA}} = |\varepsilon(\vec{r})^t - \varepsilon(\vec{r})|$
– $\forall \vec{r} \in \mathbb{I},\ E_{\omega}^{\text{STEM Moiré GPA}} = |\omega(\vec{r})^t - \omega(\vec{r})|$

Test 8 looks more like a validation test than a verification test. Nevertheless, Test 8 is highlighting the accuracy (with no noise), and the precision (with noise) of STEM Moiré GPA seen by the end-user (code, user and algorithm errors included). The performance is then characterized as the error output function of the noise (or of the quality factor of $I_{SMH_{\text{exp}}}$ like the signal on noise ratio $SNR = \frac{I_{SMH_{\text{exp}}}}{N}$). The performance characterization can be used to see from which quality factor the accuracy and sensitivity of STEM Moiré GPA is too poor to consider the strain and rotation results reliable and warn the user in this case. The performance graph can also be as a base of comparison with another software (if it exists) doing the same data treatment.

5.3 Traceability Between Test Cases and Requirements

6 Unit Testing Plan

6.0.1 Input Verification test

Test R 2 in IM 1: Existence and Format of $I_{SMH_{\text{exp}}}$, $I_{C_{\text{ref}}}$ and p

Test 9 Test-Existence-SMH

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for $I_{SMH_{\text{exp}}}$ user input
- ⋆ Input: $I_{SMH_{\text{exp}}} = \emptyset$
- ⋆ Output: Error message $Err_{I_{SMH_{\text{exp}}}}$ should match: "No STEM Moiré hologram, please load a proper image"

Test 10 Test-Format-SMH

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for $I_{SMH_{\text{exp}}}$ user input
- ⋆ Input: Various $I_{SMH_{\text{exp}}}$ improper format

- ⋆ Output: Error message $Err_{I_{SMH_{\exp}}}$ should match: "Invalid STEM Moiré hologram format (expecting a 2D array)"

Test 11 Test-read-dm3-format

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for $I_{SMH_{\exp}}$ or $I_{C_{\text{ref}}}$ user input
- ⋆ Input: Pre defined random 2D array in dm3 format with specific tags (calibration, microscope, high tension, ...)
- ⋆ Output: Read the tag from the dm3 file and and test each tag collected with the pre defined tags

Test 12 Test-Existence-pixel

- ⋆ Type: Dynamical
- ⋆ Initial State: After importing $I_{SMH_{\exp}}$ and format validated
- ⋆ Input: p=$\emptyset$
- ⋆ Output: Error message Err_p should match: "No pixel size found"

Test 13 Test-Format-pixel

- ⋆ Type: Dynamical
- ⋆ Initial State: After importing $I_{SMH_{\exp}}$ and format validated
- ⋆ Input: Improper format of p
- ⋆ Output: Error message Err_p should match: "Invalid pixel size"

Test 14 Test-Format-Reference

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for $I_{C_{\text{ref}}}$ user input
- ⋆ Input: Various $I_{C_{\text{ref}}}$ improper format

- ⋆ Output: Error message $Err_{I_{C_{\text{ref}}}}$ should match: "Invalid Reference image format (expecting a 2D array)"

Test 15 <u>Test-Existence-Reference</u>

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for $I_{C_{\text{ref}}}$ user input
- ⋆ Input: $I_{C_{\text{ref}}} = \emptyset$
- ⋆ Output: Error message $Err_{I_{C_{\text{ref}}}}$ should match: "No Reference image, please load a proper image"

Test R 6 in IM 2: Test of the mask user input

Test 16 <u>Test-Existence-Mask</u>

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for M user input on $\widetilde{I}_{SMH_{\text{exp}}}$
- ⋆ Input: M=$\emptyset$
- ⋆ Output: Error message Err_M should match: "No Mask found"

Test 17 <u>Test-Format-Mask</u>

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for M user input on $\widetilde{I}_{SMH_{\text{exp}}}$
- ⋆ Input: M improper format (such as 1D array, 2D array out of bounds if
- ⋆ Output: Error message Err_M should match: "Improper mask format"

Test 18 <u>Test-Position-Radius-Mask</u>

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for M user input on $\widetilde{I}_{SMH_{\text{exp}}}$
- ⋆ Input: Mask center $=(0, 0)$, Mask radius=3
- ⋆ Output: Center of the circle mask positioned in the middle of the 2D array $\widetilde{I}_{SMH_{\text{exp}}}$ and with a radius of 3 pixels

Test R 9 in IM 3: Test of the unstrained region user input

Test 19 Test-Existence-U

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for U user input on $P_{\Delta\vec{g_j}^{M_{exp}}}$
- ⋆ Input: U=∅
- ⋆ Output: Error message Err_U should match: "No reference in phase image found"

Test 20 Test-Format-U

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for U user input on $P_{\Delta\vec{g_j}^{M_{exp}}}$
- ⋆ Input: U improper format
- ⋆ Output: Error message Err_U should match: "Improper reference in phase image format"

Test 21 Test-Position-U

- ⋆ Type: Dynamical
- ⋆ Initial State: Waiting for U user input on $P_{\Delta\vec{g_j}^{M_{exp}}}$
- ⋆ Input: Position left top corner=$(10, 10)$, Position right bottom corner=$(30, 40)$
- ⋆ Output: Rectangle center position $(20, 25)$, short length $l = 20$ pixels and longh length $L = 30$ pixels

6.0.2 Output results test

Test R 11 in IM 4: Affine vectorial transformation

Test 22 Test-Basic-affine-transformation

- ⋆ Type: Functional, Dynamical
- ⋆ Initial State:

- Input: $\overrightarrow{q_{n,m}} = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$, $\overrightarrow{g_j}^{M_{\text{exp}}}_{\text{uns}} = \Delta \overrightarrow{g_j}^{M_{\text{exp}}}_{\text{cor}} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$, $p = 3$
- Output: $\overrightarrow{g_j}^{C_{\text{exp}}}_{\text{uns}} = \Delta \overrightarrow{g_j}^{C_{\text{exp}}} = \begin{bmatrix} 4 \\ -5 \end{bmatrix}$

TestR 12 in IM 5: Strain and rotation calculation

Test 23 Test-No-2D-strain

- Type: Functional, Dynamical
- Initial State:
- Input:
  - $G^{\text{exp}}_{\text{uns}} = \begin{bmatrix} g^{C_{\text{exp}}}_{1_{\text{uns}_x}} & g^{C_{\text{exp}}}_{2_{\text{uns}_x}} \\ g^{C_{\text{exp}}}_{2_{\text{uns}_x}} & g^{C_{\text{exp}}}_{2_{\text{uns}_y}} \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$
  - $\Delta G^{\text{exp}}(\vec{r}) = \begin{bmatrix} \Delta g^{C_{\text{exp}}}_{1_x}(\vec{r}) & \Delta g^{C_{\text{exp}}}_{1_y}(\vec{r}) \\ \Delta g^{C_{\text{exp}}}_{2_x}(\vec{r}) & \Delta g^{C_{\text{exp}}}_{2_y}(\vec{r}) \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$
- Expected output:
  - $\forall \vec{r} \in \mathbb{I},\ \varepsilon^{\text{exp}}(\vec{r}) = \begin{bmatrix} \varepsilon_{xx^{\text{exp}}}(\vec{r}) & \varepsilon_{xy^{\text{exp}}}(\vec{r}) \\ \varepsilon_{xy^{\text{exp}}}(\vec{r}) & \varepsilon_{yy^{\text{exp}}}(\vec{r}) \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$
  - $\forall \vec{r} \in \mathbb{I},\ \omega^{\text{exp}}(\vec{r}) = \begin{bmatrix} 0 & \omega_{xy^{\text{exp}}}(\vec{r}) \\ -\omega_{xy^{\text{exp}}}(\vec{r}) & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$

Test 24 Test-known-constant-2D-strain

- Type: Functional, Dynamical
- Initial State:
- Input:
  - $G^{\text{exp}}_{\text{uns}} = \begin{bmatrix} g^{C_{\text{exp}}}_{1_{\text{uns}_x}} & g^{C_{\text{exp}}}_{2_{\text{uns}_x}} \\ g^{C_{\text{exp}}}_{2_{\text{uns}_x}} & g^{C_{\text{exp}}}_{2_{\text{uns}_y}} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

– Various $\Delta G^{\exp}(\vec{r}) = \begin{bmatrix} \Delta g_{1_x}^{C_{\exp}}(\vec{r}) & \Delta g_{1_y}^{C_{\exp}}(\vec{r}) \\ \Delta g_{2_x}^{C_{\exp}}(\vec{r}) & \Delta g_{2_y}^{C_{\exp}}(\vec{r}) \end{bmatrix}$

  * Uniaxial strain along $\vec{u_x}$, $\Delta G^{\exp}(\vec{r}) = \begin{bmatrix} 0.1 & 0 \\ 0 & 0 \end{bmatrix}$
  * Uniaxial strain along $\vec{u_y}$, $\Delta G^{\exp}(\vec{r}) = \begin{bmatrix} 0 & 0 \\ 0 & 0.1 \end{bmatrix}$
  * Pure shear strain, $\Delta G^{\exp}(\vec{r}) = \begin{bmatrix} 0 & 0.1 \\ 0.1 & 0 \end{bmatrix}$
  * Pure rotation, $\Delta G^{\exp}(\vec{r}) = \begin{bmatrix} 0 & 0.1 \\ -0.1 & 0 \end{bmatrix}$

⋆ Expected output:

– Uniaxial strain along $\vec{u_x}$,

$$\begin{cases} \forall \vec{r} \in \mathbb{I},\ \varepsilon^{\exp}(\vec{r}) = \begin{bmatrix} -\frac{1}{11} & 0 \\ 0 & 0 \end{bmatrix} \\ \forall \vec{r} \in \mathbb{I},\ \omega^{\exp}(\vec{r}) = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{cases}$$

– Uniaxial strain along $\vec{u_y}$,

$$\begin{cases} \forall \vec{r} \in \mathbb{I},\ \varepsilon^{\exp}(\vec{r}) = \begin{bmatrix} 0 & 0 \\ 0 & -\frac{1}{11} \end{bmatrix} \\ \forall \vec{r} \in \mathbb{I},\ \omega^{\exp}(\vec{r}) = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{cases}$$

– Pure shear strain,

$$\begin{cases} \forall \vec{r} \in \mathbb{I},\ \varepsilon^{\exp}(\vec{r}) = \begin{bmatrix} 0 & -\frac{1}{11} \\ -\frac{1}{11} & 0 \end{bmatrix} \\ \forall \vec{r} \in \mathbb{I},\ \omega^{\exp}(\vec{r}) = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{cases}$$

– Pure rotation,

$$\begin{cases} \forall \vec{r} \in \mathbb{I},\ \varepsilon^{\exp}(\vec{r}) = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \\ \forall \vec{r} \in \mathbb{I},\ \omega^{\exp}(\vec{r}) = \begin{bmatrix} 0 & \frac{1}{11} \\ -\frac{1}{11} & 0 \end{bmatrix} \end{cases}$$

⋆ Output: $\varepsilon^{\exp}(\vec{r})^t - \varepsilon^{\exp}(\vec{r}), \omega^{\exp}(\vec{r})^t - \omega^{\exp}(\vec{r})$ and test them to be 0
The special case with $det(G^{\exp}_{\text{uns}} + \Delta G^{\exp}) = 0$ should be also tested.

Test 25 Test-Improper-$\Delta G^{\exp}$

⋆ Type: Functional, Dynamical

⋆ Initial State: Whatever $\Delta G^{\exp}(\vec{r})$

⋆ Input:

– $G^{\exp}_{\text{uns}} = \begin{bmatrix} g^{C_{\exp}}_{1_{\text{uns}_x}} & g^{C_{\exp}}_{2_{\text{uns}_x}} \\ g^{C_{\exp}}_{2_{\text{uns}_x}} & g^{C_{\exp}}_{2_{\text{uns}_y}} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$

⋆ Output: Error message $Err_{G^{\exp}_{\text{uns}}}$ should match: "Matrix $G^{\exp}_{\text{uns}}$ non invertible, the crystalline wave vectors are liked (collinear). Please chose another combination of crystalline wave vectors."

Test 26 Test-Improper-$G^{\exp}_{\text{uns}}$

⋆ Type: Functional, Dynamical

⋆ Initial State:

⋆ Input:

– $\Delta G^{\exp} + G^{\exp}_{\text{uns}} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$

⋆ Output: Error message $Err_{\Delta G^{\exp}}$ should match: "Matrix $G^{\exp}$ non invertible. If $G^{\exp}_{\text{uns}}$ is invertible, something is probably wrong with $\Delta G^{\exp}$."

7 Appendix

This is where you can place additional information.

7.1 Symbolic Parameters

The definition of the test cases will call for SYMBOLIC_CONSTANTS. Their values are defined in this section for easy maintenance.

7.2 Usability Survey Questions?

This is a section that would be appropriate for some teams.